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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

SEPTEMBER 4-22.

Fifth German Foundry Exhibition at Düsseldorf.

SEPTEMBER 9-12.

Institute of Metals:—Annual Autumn Meeting in Düsseldorf.

SEPTEMBER 10-13.

Iron and Steel Institute:—Autumn meeting at Newcastle-upon-Tyne.

SEPTEMBER 12-28.

Shipping, Engineering and Machinery Exhibition at Olympia, London.

No Valid Reason.

Whilst the quantity-production foundries of Great Britain are mechanising their shops as fast as trade and other conditions will allow, the rest, with a few notable exceptions, stress the impossibility of utilising conveyors on the grounds that they are really jobbing shops.

The problem as to whether a conveyor is or is not worth while is governed by the quantity of similar-sized material to be moved from one place to another in the course of a long period. Thus, so far as the production of liquid metal by the cupola is concerned, there is practically no difference between the speciality and the jobbing foundry, except that the former is more constant in its demands. This factor is, however, of little consequence. It is this common ground which we feel should be studied by all large foundries, no matter what the character of the output may be. Pig-iron, coke, scrap and limestone have to be taken from their arrival point and be charged into the cupola, and this is a comparatively simple and relatively inexpensive matter, if one permits of the assumption that one can spend £1,000 to eliminate one labourer, who, after all, is doing hard and uninteresting work. A comparison of the two following typical foundries gives food for thought, both having sidings running alongside the foundry buildings. Foundry A unloads its pig-iron by a magnet; its coke by tippling a loaded wagon in such a manner as to prevent serious breakage. Then the pig-iron is broken and conveyed to the charging stage; the coke automatically riddled and treated similarly.

Foundry B unloads its pig-iron *by hand*, stacks it *by hand*, loads into barrows *by hand*, wheels it to the hoist, empties the contents on to the stage; stacks it on to a weighing machine *by hand*, carries from the weighing machine to the charging door *by hand*. The coke is similarly dealt with, except that it may not be weighed. The handling of new sand, and the knocking out of castings (except, perhaps, the very largest), are operations common to both jobbing and speciality foundries, and are usually amenable to mechanisation. The number of types of conveyors available for the foundry industry—bucket, plate, pendulum, steel band, monorail, telpher—is generally insufficiently appreciated. Moreover, we find that the makers are in general only too ready to co-operate with each other to give the user a unified system of "flow" for the complete operation of the work susceptible to mechanical handling.

Finally, it is time that it was recognised that an insistence upon being a jobbing foundry is no valid reason for the dismissal of the question of mechanisation as unpractical.

Human Raw Material.

A good many people have been somewhat concerned by the recent Government announcement that the school-leaving age is shortly to be raised to 15. The announcement may be considered to be made largely to amplify a pre-election pledge, a pledge given in response to the very common view that the longer the period of education the better for the child, and that raising the school-leaving age will automatically reduce educational-social differences as between one class of the community and another. Up to a point, anything person must sympathise with this view, but it is doubtful whether a mere extension of the existing educational facilities will be as advantageous as a similar measure would certainly be if it were accompanied by a reshaping of the upper end of the existing primary system in order to make it more useful to boys subsequently entering industry. Two main arguments may be advanced to reconcile the proposal to the existing needs of the community. The first is that many young people cannot begin their formal apprenticeship in industry until 16, nor is it desirable that they should do so, in view of the trade custom that 20 or 21 is the end of the apprenticeship period, and the adequacy of four or five years' training under modern conditions. The years from 14 to 16 are, therefore, an awkward period to fill, and the boy frequently drifts into undesirable blind-alley occupations or does miscellaneous work of a "picking-up" character. In the second place, the present extent of unemployment really does give reason to such an action as this of raising the school age. The effect of such a step will be twofold. Firstly, it will directly reduce the volume of juvenile unemployment, which is perhaps the most distressing aspect of the whole question. Secondly, by reducing the supply of juvenile labour, it will make it less easy for employers to make casual use of cheap boy labour. We have frequently had cause to regret that employers as a group have expressed no views on the question of the part-time education of industrial boys between the ages of 14 and 16. This was proposed by the Fisher Act of 1918, but never put into force, and there is little doubt that it would have become effective had employers as a body expressed any anxiety in the matter. Moreover, it might well have proved an infinitely preferable alternative to the general raising of the school-leaving age. Naturally, such a measure would have involved considerable difficulties, chief of which was that the boy had to have two half-days a week off for educational attendance. Nevertheless, it is not unreasonable to suggest that even greater difficulties may yet arise through the divorce of interests that results from the lack of co-operation and mutual understanding between industry and education. What is more, the raising of the school age, which might never have come about had the Fisher Act been in force, may well bring its own difficulties of as serious a nature. Too many employers in the past have regarded the casual employment of juvenile labour as a matter of course. The combination of a higher school-leaving age and a lower birth-rate will very soon combine to place a premium on juvenile labour, which will gravitate to the shops where it obtains the best treatment, leaving the casual employer of the old type unsupplied.

XUM

High-Test Grey Cast Iron—European Developments.*

By Edward E. Marbaker,† Ph.D., Pittsburgh, Pa.

Introduction.

While the manufacture of grey-iron castings is one of the oldest industries, it is only within recent years that serious attempts have been made to improve its properties. This improvement has been fostered by the commercial necessity for better castings, and by the increased knowledge of the metallurgy of steel. It has long been known that the strongest steel exhibits a pearlitic structure which appears under favourable conditions when the carbon content is 0.90 per cent. It has been found that the basic ground-mass in cast iron is also pearlitic, but that it can be brought out only under very carefully controlled conditions. Cast iron also contains much higher contents of carbon than steel, and a part of this is combined with iron, the remainder existing as graphite which occurs generally in the form of plates. The structure of cast iron is therefore not as continuous as that of steel, and the fact that it is not as strong is thereby accounted for. It was necessary for investigators to discover means for controlling the structure of the ground-mass, and the form and distribution of the graphitic carbon in order to obtain cast iron of high strength and with other improved qualities.

Goerens showed in 1906 that cast iron in order to possess the best strength properties should have a pearlitic structure. The examination of many castings served to prove his contention, but no method of ensuring the desired structure in every casting had been worked out. It was also shown that it would be highly desirable to change the form and distribution of the graphite. The improved strength of malleable iron due to the presence of carbon in the form of fine grains, called temper carbon, demonstrates this. Since 1906 many attempts have been made to follow out the ideas of Goerens systematically, and there are now available a considerable number of methods for the manufacture of cast iron possessing improved properties, which has come to be known as high-test cast iron.

The methods now known may be divided roughly into six classes, as follows:—(1) Decrease of carbon content; (2) control of cooling rate after casting; (3) reduction of particle size of graphite and improvement of distribution by (*a*) superheating, (*b*) rapid cooling of high-silicon iron, and (*c*) treatment with calcium silicide; (4) alloying with elements such as nickel and chromium; (5) agitation of molten iron; and (6) eutectic cast iron. Each of these groups will now be considered briefly.

Decrease of Carbon Content.

Since steel contains no graphite and is strong, it is obvious that attempts should have been made to decrease the carbon content of cast iron. This has generally been attained by large steel additions to the charge, and the resulting material has been called semi-steel, and synthetic cast iron. No special apparatus is required for melting, but the cupola must be operated very efficiently from the standpoint of combustion in order to attain the requisite temperature, since the steel mix melts at a higher temperature than ordinary cast iron. Because of this fact the electric furnace has had a wide application in this field. It has another advantage in that the carbon pick-up, which must be taken into account in cupola melting, is obviated. In general the results of melting in the electric furnace have been better than those attained in cupola melting, and this may be attributed to the higher superheat which is attainable.

The investigations of Wüst have shown that the results are best when the carbon content is between 2.2 and 3.0 per cent., silicon 2.2 and 1.2 per cent., and manganese 1.0 per cent. The structure consists mainly of pure pearlite with fine and scanty graphite interspersions. As the carbon is decreased the manganese should increase.

Technically this theory is represented by semi-steel, the Sternguss of Krupp, Emmel's process, Meehanite, and the Corsalli process. The last-mentioned product also falls into the classification of iron produced by superheating. The technology of semi-steel has been worked out to a great extent in America, as is also the case with Meehanite, which is made by the addition of calcium silicide to the molten iron. The Krupp, Emmel and Corsalli processes were worked out in Germany and have been widely discussed in the literature. The analysis and properties of the cast iron made by these methods is shown in Table I.

Table I.

	T.C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.	Modulus of rupture. Tons per sq. in.	Tensile strength. Tons per sq. in.
Semi-steel:							
Cupola (25 per cent. steel)	3.11	2.24	0.44	0.08	0.48	25.1	15.1
Electric furnace ..	3.12	2.23	0.64	0.042	0.42	31.2	—
Krupp Sternguss ..	2.4—2.7	1.86—2.33	0.86—1.46	0.08—0.13	0.11—0.24	40.6	22.3
Emmel (50 per cent. steel)	2.64	2.14	1.37	0.16	0.25	—	23.4
Meehanite	2.4—2.7	1.30—1.80	0.50—1.00	0.08—0.14	0.12—0.20	39.3	—
Corsalli	2.73	2.20	1.34	0.11	0.26	37.4	23.2

Control of Cooling Rate after Casting.

Diefenthaler and Sipp followed systematically the ideas of Goerens and sought to produce a cast iron which would always exhibit an all-pearlitic structure regardless of thickness of section. In 1916 the first of the series of patents covering pearlitic cast iron was granted to them. The process covers the use of a low-silicon mixture, and the cooling of the castings in previously heated moulds in accordance with a definite schedule depending upon the thickness of section. The principal characteristic of this iron is that if it were cooled normally it would solidify as white iron, but when cooled in preheated moulds it solidifies as grey iron. The structure is completely pearlitic, and the graphite appears in small flakes, uniformly distributed. In general a normal cupola charge is used which is so arranged that the graphite formation is stimulated as little as possible. The total content of carbon plus silicon is 4 per cent. ($C \leqq 3.5$ per cent., $Si \leq 1.5$ per cent.). The cooling rate required by different wall thicknesses is obtained by heating the moulds to experimentally-determined temperatures. For very thin walls, which will cool too quickly, a softer charge is used in which the sum of the carbon and silicon is 4.6 per cent. ($C \leq 3.5$ per cent., $Si \leq 1.12$ per cent.), and for thick walls a harder charge in which the sum of the carbon and silicon is 3.4 per cent. or less ($C \leq 2.9$ per cent., $Si \leq 0.9$ per cent.). Curves showing the required mould temperatures for all compositions and wall thicknesses were plotted. It was stipulated that the pouring temperature should be 280 deg. C. above the melting point of the iron.

The analysis and properties of cast iron made by this method, which is usually called the Lanz-Perlit process, are as follow:—T.C. 3.25, Si 1.11, Mn 0.79, S 0.15, and P 0.40 per cent.

(1) High modulus of rupture (17.9 to 35.7 tons per sq. in.) and tensile strength (13.4 to 22.3 tons per sq. in.); toughness; (2) high resistance to impact; (3) moderate hardness and high degree of machinability; (4) resistance to abrasion; and (5) fine, dense structure which is unaffected by temperature changes.

The Lanz process is complicated and requires much care in manipulation, but the results appear to justify it.

Since the preheating of moulds and the very careful control of the mixture is troublesome, later investigators have tried to show that the all-pearlitic structure can be obtained by less cumbersome methods. Maurer and Emmel show that with similar composition of materials and without preheating of moulds, the pearlitic structure can be obtained within the widest limits of casting section, and the structure is uniform. It appears from this that some other factor than the mere preheating of moulds is responsible. In the case of Krupp and Emmel iron, which are cast at much higher temperatures than Lanz "Perlit" iron, it appears that the superheating may be the effective agency, and it would seem that essentially the Lanz process is a form of heat treatment. It is certain that the castings made by the processes so far mentioned have much the same composition and properties, and the structure is all-pearlitic in each case.

Reduction of Particle Size of Graphite and Improvement of Distribution.

The properties of malleable cast iron have long been attributed to the finely divided form and the uniform distribution of the graphite (temper carbon), and investigators naturally reasoned that the production of grey cast iron containing the graphite in an analogous form would result in an improvement of properties. Goerens declared that the form of graphite theoretically can be influenced without resorting to heat treatment as in the case of malleable iron. There are three ways in which this can be carried out:—(*a*) Superheating of the molten iron, (*b*) rapid cooling of molten high-silicon iron, and (*c*) treatment of molten metal with calcium silicide.

Superheating of the Molten Iron.—Piwowarsky and Hanemann have shown that superheating influences the form and quantity of graphite. With rising temperature of superheat the graphite grains become finer and finer with the temper-carbon-like graphite eutectic as the limit. The formation of iron carbide (cementite) increases and then decreases as the temperature rises. With material containing 0.06 per cent. silicon the transition point lies at 1,500 deg. C. Below this temperature the melt has a tendency to solidify carbidic, while above it the tendency is towards increased graphite separation. The transition point is not changed by increasing the time of heating for the same analysis, but at lower temperatures continued heating acts in the same way on carbide formation as temperature elevation. An increase of silicon from 0.06 to 2.35 per cent. changed the transition temperature from 1,500 to 1,400 deg. C. This pheno-

* A Paper read before the Annual Meeting of the American Foundrymen's Association.

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menon has given rise to the theory that the usual non-uniformity of the metal and the difficulty in reproducing results in the foundry are due to the fact that the iron is not heated to a sufficiently high temperature to bring about the complete solution of the carbon and to attain the degree of homogeneity of the melt which is desirable. When, however, the iron is superheated, a homogeneous melt is produced, and on cooling the crystallisation of graphite proceeds from tiny nuclei and the resulting crystals are small and evenly distributed. The degree of superheat determines the amount and fineness of the graphite present. On cooling from high temperatures, 1,482 to 1,705 deg. C., the graphite is deposited in very fine crystals of the temper-carbon form, and the properties of the metal are thereby greatly improved. The rate of cooling should be slow enough to allow the solid solutions to become saturated, and this ensures equilibrium in the finished casting.

The superheating may be carried out in the standard cupola by decreasing the melting ratio, but here care must be taken that too much carbon is not absorbed from the coke. The Emmel process depends to some extent upon superheating of the molten iron in the cupola, and the specification of the patent includes definite directions for the operation of the cupola. It would seem to be preferable to use one of the many types of forehearth which are heated independently, since in this way the carbon content can be controlled. The Wüst oil-fired furnace, which is a combination of stack and air-furnace hearth, has been successfully used because no coke is used and there is little chance for the metal to pick up carbon. The electric furnace has also shown successful results, especially when the duplexing process (melting in the cupola and superheating in the electric furnace) is used. It is probable that the superior properties of semi-steel are due to superheating in addition to the benefit which is derived from the low carbon content.

The Corsalli process affords another means of obtaining superheat in the standard cupola. Extremely high blast pressures are used, and the silicon and manganese which are burned out are replaced by the introduction of ferro-alloys into the melting zone by means of a specially constructed apparatus affixed to the cupola and connecting the charging door with the melting zone directly.

The analysis and properties of the high-test grey cast iron produced by superheating are shown in Table II.

Rapid Cooling of High-Silicon Iron—Schüz Graphite Eutectic.—Schüz proposes that the structure of the casting be controlled by utilising a mixture of definite composition and pouring into chills. The structure is not pearlitic, but a eutectic of ferrite and graphite. This iron is stated to possess a stable structure and to be constant in volume at high temperatures. The iron contains 3.6 per cent. carbon and 3.3 per cent. silicon. The modulus of rupture was 120,000 lbs. per sq. in., and the tensile strength 23.0 tons per sq. in. The final product has a structure and properties comparable to malleable iron, but it is to be noted that the silicon is very high.

Treatment with Calcium Silicide.—In this process, by which a special cast iron called Meehanite is produced, the mixture is melted in the cupola, air furnace, or in the electric furnace, and calcium silicide is added in the ladle. The product exhibits structure similar to that of Krupp Sternguss, or Emmel iron. The modulus of rupture extends from 83,500 to 100,000 lbs. per sq. in. The carbon content is 2.2 to 2.7 per cent. and the silicon 1.03 to 1.80 per cent., depending upon the type of furnace used for melting. This type of high-test cast iron is an American product, and as such its discussion is out of place in this Paper. It is merely mentioned as an example of a method different from any yet described by which high-test cast iron may be produced.

Alloying with Elements such as Nickel and Chromium.

The improvements in the properties of grey cast iron brought about by the addition of alloying elements to iron melted in the cupola have been worked out principally in America, although a great deal of corroborative work has been carried on in Germany and in England under the auspices of the British Cast Iron Research Association. Such alloy cast irons do not depend particularly upon the formation if pearlitic structure, but more upon the control of the graphite form and distribution. This method is mentioned only in passing because, being in general an American development, it has no real place in this Paper.

Table II.

	T.C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.	Modulus of rupture. Lbs. per sq. in.	Tensile strength. Tons per sq. in.	Transverse strength. Lbs. per sq. in.
Cupola (Emmel)	2.64	2.14	1.37	0.16	0.25	—	23.4	—
Electric furnace	3.12	2.23	0.64	0.04	0.42	69,900	—	4,480
Duplex process	3.33	2.01	0.54	0.03	0.55	—	—	4,287
Corsalli process	2.73	2.20	1.34	0.11	0.26	83,760	23.3	—
Wüst oil-fired furnace ..	2.70	1.67	0.96	0.07	0.39	78,500	20.9	—
Cupola (semi-steel).. ..	3.11	2.24	0.44	0.08	0.48	56.200	15.	—

Agitation of Molten Iron in the Forehearth.

Considerable attention has been given in the literature to the process of agitating molten cast iron in the forehearth which was worked out in Germany by Deschene. This method of producing high-test grey cast iron differs materially from the other processes which have been described. The essential feature of the process is a forehearth which is so arranged that the metal which is drawn from the standard cupola is subjected to violent jolting. In the other process, the cast iron is improved by chemical and thermal means; in this process the operation is entirely mechanical. The value of the method lies in the fact that the molten iron is thoroughly mixed, gases are eliminated, the sulphur is rendered innocuous by more perfect slagging, and the carbon is brought into more nearly complete solution. The process is worked out more or less independently of the mixture charged into the cupola.

It is stated that whether the iron contains 3.2 or 3.6 per cent. carbon, 1.6 or 2.6 silicon, the following properties are obtainable with the normal casting temperature of 1,343 to 1,400 deg. C.; tensile strength 18.8 to 25.5 tons per sq. in.; modulus of rupture 71,000 to 85,000 lbs. per sq. in. The Brinell hardness varies between 180 and 240. Castings may be made in green sand or dry sand moulds. The castings exhibit a dense pearlitic structure and a fine fracture, piping being almost entirely absent.

Eutectic Cast Iron.

When the various processes for the production of high-test grey cast iron are carefully analysed, it becomes apparent that there must be some common denominator, some theory which fits all the cases. Very recently Mitinski[1] published a Paper in which he pointed out that from theoretical reasoning, eutectic cast iron should be sought in making stress-free, high-test grey iron castings. It is known that the carbon content of the eutectic alloy of iron and carbon is 4.3 per cent. This is decreased by the addition of silicon and other elements. For instance, 1 per cent. silicon reduces the eutectic composition to 3.88 per cent. carbon, and 2 per cent. further reduces it to 3.63 per cent. For 2 per cent. silicon and 1 per cent. phosphorus the eutectic contains 3.33 per cent. carbon.

Osann,[2] in a more recent Paper, follows the same general idea and elaborates it. In the Lanz, Emmel and Krupp processes the pearlitic structure is obtained, but in the irons of higher silicon content the graphite is not lamellar, but granular. These irons are claimed not to grow under conditions of repeated heating and cooling, they do not pipe or shrink. Osann holds that the reason for the two latter properties is that the irons are eutectic alloys. Only eutectic alloys have these properties, but other good properties are possessed as well, and they also preclude the formation of coarse, lamellar graphite.

Lanz, Krupp, Emmel and Schüz irons are obtained by adjustment of the carbon and silicon contents. The same result may be brought about by superheating and the jolting of the liquid metal. Piwowarsky found that up to 1,500 deg. C. the graphite decreases and combined carbon is formed while the residual graphite is fine-grained. Hanemann tried to account for the facts by the germ theory of crystallisation, but Osann does not accept this because of the doubt as to the origin of the nuclei. Sometimes superheating fails to achieve its purpose, and success seems impossible unless 30 per cent. or more steel scrap is added to the melt. The same object can be attained, says Osann, without recourse to the expensive process of superheating, and in this connection he draws attention to the difference between kish graphite and solid solution graphite. By the latter is meant the graphite liberated by the dissociation of cementite in the solid state. It is the kish graphite which causes poor strength, wear and frictional properties which must be present to satisfy the requirement of the high-test grey cast irons, such as Lanz "Perlit," for instance.

The nuclei of Hanemann are essentially kish graphite crystals which persist during the operation of remelting. They may also be segregated phosphide eutectic or manganese sulphide.[3] These concomitants are usually kept low in high-test cast iron. It is, therefore, necessary to see that kish graphite is not formed at the outset. It will then be unnecessary to superheat for the destruction of the nuceli. Attempts should be made to obtain eutectic graphite, and the composition of the cast iron should be regulated accordingly. The trouble starts with the pig-iron, which contains too much carbon in this day of frequent tapping and high hearth temperature.

According to Morschel, in a cast iron containing 2.8 per cent. silicon, which solidifies with a grey fracture, or, in other words, tends to the formation of graphite, kish graphite crystals separate from the melt when the carbon content is greater than 3.1 per cent., and these crystals are present during solidification. These graphite crystals give rise to a faulty structure, either indirectly in the form of nuclei as indicated by Hanemann, or directly in the form of extraneous matter. With any cast iron containing 3.75 per cent. carbon, there is present 3.75 minus 3.1 or 0.65 per cent. carbon in the form of kish. With a different composition the eutectic point is displaced towards a lower carbon content. A number of practical cases are cited in which the kish was removed and the graphite content re-

[1] See F.T.J., December 6, 1928, p. 413.
[2] See F.T.J., December 20, 1928, p. 448.
[3] This statement requires elaboration before acceptation.—Editor, F.T.J.

duced, not by superheating, but by allowing the iron to stand and considerably retarding cooling.

It is not by mere chance that steel scrap in the cupola or in the electric furnace can be carburised up to a definite limit. The eutectic point is reached at 2.7 to 2.9 per cent. carbon, and it is impossible to go farther because the iron can dissolve no more carbon. In the ideal state, pearlitic iron represents a eutectic alloy from which kish is excluded, and the same applies to other high-test irons as well. In Emmel iron the carbon is low in conformity with the increased percentage of silicon. The compositions of the eutectic cast-iron alloys are not known. There is no single alloy, but a large number, because each of the different silicon and phosphorus contents has its own eutectic carbon content. In order not to complicate the matter manganese and sulphur are assumed to remain constant. In this way there should be at least nine different diagrams.

Eutectic alloys do not pipe, and this quality can be taken as a critical test of eutectic cast iron. Lanz and Emmel irons come into this category. All the various methods for the production of high-test grey cast iron meet at this point, and this is the common denominator which was sought. Consciously or unconsciously, all processes for the improvement of the properties of cast iron have been directed towards a eutectic composition, because it has the advantage of the lowest melting point, it pours well because there are no free crystals in the molten mass, and the liquid solidifies without any auxiliary agency. A eutectic alloy, therefore, fills out the finest contours. After it has cooled this alloy exhibits the best strength qualities and the best conditions of structure to withstand friction and wear because the molecules are able to arrange themselves undisturbed in the state of equilibrium. There is thus no possibility of segregation of piping and the shrinkage is at a minimum.

Piwowarsky advocated the superheating of iron and referred to the time factor. It may be that this result was not due so much to the superheating as to the elimination of kish graphite, and consequently the reduction of the carbon content. Superheating would simply shorten the time necessary. It would appear that the time-honoured adage of "Melt hot and allow the iron to stand" has now been given a scientific foundation. In the Deschene process the separation of kish and sulphur is assisted by the fact that the iron is kept hot and in motion, and thus the desired result is brought about in a minimum time.

Conclusion.

The methods of producing high-test grey cast iron are numerous, and considerable differences among them are to be noted. The resulting castings have much the same structure and properties, which points to some underlying general theory as pointed out by Osann. The subject is still in a controversial stage, but it is quite evident that ways and means are now available for the production of better castings. Unfortunately the methods which have been proposed cannot be carried out without additional expense, but when it is considered that the quality of the product is made more uniform and certain, there should be no lack of interest on this account.

Abrasion of Steel.—According to a Paper by Messrs. Derry and Darnell, published in the Proceedings of the Engineers' Society of Western Pennsylvania, extensive research has been conducted to find metals or other materials which would resist abrasion. Many alloy steels were examined, but it was very soon discovered that the harder the steel the greater the abrasive effect. This is, it is suggested, due to the fact that as the abrasive particle travels over the steel it chips off the hard metal and carries it away, while with the soft steel it merely makes a groove as a plough goes through the land.

Catalogues Received.

Non-Ferrous Alloys.—The Atlas Metal and Alloys Company, Limited, of 1, Central Buildings, Westminster, London, S.W.1, have prepared a 12-page booklet detailing the uses and mechanical characteristics of a number of proprietary brands of alloys for bearings.

Brushes.—Ernest W. Perrett, Limited, of 68, East India Dock Road, London, E.14, have sent us a copy of their abridged list No. 27. This is definitely a utilitarian type of catalogue, in which such items as wire scratch brushes and various sorts of moulders' brushes are illustrated and the price attached. All their manufactures carry the trade mark "Squirrel." It contains 24 pages and practically every article is illustrated.

Patternmaking.—A folder dealing with Titanite, the well-known stone mixture for patternmaking, has been prepared by the Constructional Engineering Company, Limited, of Charles Henry Street, Birmingham. The inside centre panel gives such technical details as "40,000 moulds from one pattern," "does not contract" and the like, whilst the outer ones give quotations from testimonials and reproductions from the order-book. The back page carries a few representative illustrations, a price list, and a résumé of other manufactures. It is a well-thought-out pamphlet and can be relied upon to stimulate interest in the company's products.

Metal Depositing.—Messrs. Fescol, Limited, of 101, Grosvenor Gardens, London, S.W.1, have sent us a 10-page well-illustrated pamphlet dealing with the Fescol Process. Some few years ago we personally investigated the process and satisfied ourselves that it was of considerable commercial utility for restoring worn shafting and the like to its original dimensions. The catalogue under review emphasises the triple aspect of the process. The one just noted, protection against corrosion and decoration. The illustrations are particularly enlightening as to the applications of the process. Page 15 illustrates a casting which has been coated both internally and externally with copper.

Firebrick Bond.—Messrs. J. H. Sankey & Son, Limited, of Canning Town, London, E., have used a 24-page, well-illustrated brochure as means of emphasising the technical attributes of Pyruma. The front cover, which carries the caption "Lowering Furnace Maintenance Costs," is particularly attractive, and the artist is to be congratulated on having drawn into his picture of a blast-furnace plant a live atmosphere. This is quite a pleasant change after the morbid relics one is accustomed to seeing in metallurgical literature. The introduction is well written and calculated to arouse interest in the subject. The only comment we would make is that, instead of emphasising "Please read on," we suggest its deletion, as it sounds a little apologetic, as though the previous matter had failed in its purport.

Stainless Steel.—A 16-page pamphlet dealing with Maxilvry malleable stainless steel has been issued by the patentees and manufacturers, Edgar Allen & Company, Limited, Imperial Steel Works, Sheffield. The booklet is admirably written and excellently arranged. As a protagonist of the foundry industry, we have just one adverse comment to make. When dealing with the forms in which Maxilvry steel is supplied, the enumeration reads "billets for drop-forging, bars, plates, sheets, forgings, castings and angles." We would not mind the placing of "casting" in the final position, but to sandwich in between "forgings" and "angles" is too bad! Especially is this the case with Maxilvry steel, as the mechanical properties are excellent in the "as cast" condition, and the difference between them as such and after forging is materially less than with ordinary steel castings.

Random Shots.

If there is one occupation in the world that might reasonably be considered the preserve of brawn rather than brain, that occupation is surely stoking. Yet the Admiralty recently issued an order to its recruiting officers to the effect that stoker candidates must be fully up to the required standard of intelligence. "The work of the stoker," they say, "has changed considerably since the days of coal-burning ships. His intelligence and his educational knowledge have to be much higher than in former years." An interesting commentary on the wails of those gloomy prophets who tell us that the workers of the world are being reduced to the level of automata. . . . This reminded me that I saw, on a recent rare visit to "the pictures," a film of, I think, German origin, in which a plucky young couple worked their way across the Atlantic—she by doing odd jobs for the ship's cook, he by stoking. I thought at the time that even stoking wasn't such an amateur job as it looked there!

* * *

I was extremely interested in a letter which reached me last week from a reader in Madeira, where he runs a foundry as one part of his job. He says some very nice things about "Random Shots"—I am too modest to repeat them—and he sends me a most entertaining account of life in his part of the world. He asks, to point the difference between industrial life there and here, "What would the average boss say if, every time he passed through the shops, the men stopped their jobs to raise their hats? . . . Just now," he goes on, "I am short of work in the foundry, so I have turned the moulders on to painting the roof and washing the walls!" My correspondent also gives an amusing account of building Marconi's wireless station in one of the least accessible parts of the island, which necessitated as a mere preliminary the making of a road two miles long and rising 700 feet above sea-level. The use of a small motor-lorry was such a novelty that much of the material was carried up free in return for a ride down! He continues: "I am making two large oil-storage tanks . . . an aerial ropeway, threshing machines, wine presses, cooperage plant, brick and cement machinery, boiler and tank work, and all kinds of domestic heating and cooking appliances!" There's specialisation for you!

* * *

Life in Madeira, in fact, sounds anything but dull, since "there is no train to catch in the morning, no fog, snow or frost, and, except for a few weeks in the rainy season, the sun is always shining." The Austin-Seven has just been put on the market, and has been nicknamed "Little Bee" by the Portuguese, who are apparently extremely fond of witty repartee and nicknames.

* * *

I have no doubt you will be as interested as I was in this news from a foundryman who, if he isn't exactly off the map, is still near enough to the edge of it. It has reminded me vividly of the fact that these "shots" of mine find their way north, south, east, and west, wherever foundries operate, and that must be very nearly everywhere. Copies of this journal must, in fact, quite often penetrate to parts of the world where every scrap of printed English is eagerly devoured, however technical, however trivial.

* * *

May I add that "Marksman" really did appreciate hearing from his friend in Madeira, and that he, and, I am sure, his stay-at-home readers, would be equally interested in news from other parts of the world where foundries flourish.

Marksman.

Alloy Cast Steels.*

By David Zuege,† Milwaukee.

American steel-casting specifications in 1902 were far below those prescribed to-day. Typical specifications called for a minimum tensile strength of 26.8 tons per sq. in. and a minimum elongation value of 10 per cent., with no limiting values for yield point or reduction of area.

As the requirements became more severe, the quality of the cast-carbon steels became better, so that during the war the United States Government specifications called for the following minimum values for ordnance steels:—

—	Yield point. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongation in 2 in. Per cent.	Reduction of area. Per cent.
Cast steel No. 1	11.2	26.8	16	24
Cast steel No. 2	15.6	33.5	15	20
Cast steel No. 3	20.1	37.9	12	18

Even with these low values, manufacturers at times had difficulty in meeting these requirements, and were required to give the castings long and repeated treatments with little success. These failures, however, were often obscured by the demand for quantity production.

Effects of Chromium on Structure of Steels.

Although chromium is often used in conjunction with another element, a simple chromium steel may be given properties far exceeding those of a plain carbon steel. Chromium has no scavenging power but is used as a true alloying element. Chemically, chromium forms either a chromium carbide, which, in turn, dissolves in the cementite, or a complex carbide of chromium and iron. These carbides are very hard. Therefore, since the hardness which can be procured is dependent upon the carbides formed, the amount of carbon as well as the chromium content is an important limiting value for such steel.

However, chromium increases the hardness not only because of the hardness of these chromium carbides, but because it aids in the retardation of the austenite transformation. Cementite containing chromium not only goes into solution with difficulty, thus raising the critical points on heating, but once in solution does not separate out to form pearlite as readily as ordinary cementite does on cooling. Therefore, in rapid cooling it helps to prevent the transformation of the austenite, thus increasing not only hardness of the surface but depth of hardening as well. The chromium steels also have a fine structure, which produces higher static strength than the straight carbon steels, with little corresponding loss in ductility.

Effect of Nickel.

Unlike chromium, nickel dissolves in iron in all proportions and is therefore found dissolved in both the free ferrite and the pearlitic ferrite of hypo-eutectoid cast steels. The presence of this iron-nickel alloy tends to retard the austenite-pearlite transformation in cooling through the critical range and therefore its effect upon the physical properties of the steel is due not only to the added strength imparted to the ferrite, both free and pearlitic, but also to the fact that the iron-nickel alloy tends to retain the harder and stronger stages of the austenite-pearlite transformation.

Due to the fact that the nickel produces beneficial properties in the ferrite, it is a very useful element to use in combination with chromium or other elements which impart added properties through their influence upon the cementite.

Influence of Manganese.

Manganese when added to a steel in an amount in excess of that required either for deoxidation or for the conversion of the sulphur to manganese sulphide must be considered as a true alloying element. Manganese not only forms a complex iron-manganese carbide but a solid solution of manganese and iron. Manganese has a very favourable effect upon the physical properties of the pearlitic steels, causing high strength accompanied by excellent ductility.

How Vanadium Acts.

Vanadium is a very powerful deoxidising agent and it is believed that the beneficial effects obtained through its use are largely due to its elimination of impurities, although it also forms complex carbides. In rolled steels it is believed to produce a very fine grain structure. In castings it is used largely in heavy irregularly-shaped castings in which it raises the ratio of yield point to tensile strength with no decrease in ductility.

Molybdenum Hardens the Ferrite.

Swinden[1] has concluded that in the absence of chromium or excess manganese, molybdenum is diffused throughout the ferrite of the steel, to which it gives greater hardness, but that when chromium or an abnormal manganese content is present, double carbides are also formed, producing greater hardness and strength. He also found that in steels containing 1 to 8 per cent. molybdenum—a definite compound of molybdenum iron with iron was formed in cooling through the critical range. When rapidly cooled this compound assumes a "fixed" state and breaks up very slowly on drawing back after the quenching operation. Sargent[2] found the same conditions in steels containing 0.25 to 0.50 per cent. molybdenum.

The retention of such a compound through a wide range of drawing temperatures explains the fact that after quenching the molybdenum steels retain their high hardness and strength values through a very wide range of tempering temperatures. Since molybdenum steels also require a slower cooling rate to produce definite strength and hardness values than most other steels, the strains occurring in these steels after heat-treatment should be low.

TABLE I.—*Representative Physical Properties of 0.35–0.45 C, 0.18–0.25 Va. Cast Steel.*

—	Fully annealed.	Range of properties after various heat treatments.
Tensile strength, in tons ..	37.9	40.2 to 71.4
Yield point, in tons ..	22.4	26.8 to 62.5
Elongation in 2 in., per cent.	22	20 to 6
Reduction of area, per cent.	40	45 to 12
Brinell hardness No. ..	180	190 to 450
Scleroscope hardness No. ..	25	25 to 55

Vanadium Steels.

The vanadium steels have in the past been used to a considerable extent in castings where an exceptionally clean metal was desired or where castings of intricate design were required, since vanadium does not confer marked air-hardening properties. It was believed that vanadium imparted to steels the ability to resist repeated stress to a marked degree, but some recent investigators believe that its importance in this respect has been exaggerated.[3] Vanadium cast steels having a carbon content of 0.35 to 0.45 per cent. and 0.18 to 0.25 per cent. vanadium will develop the average physical properties given in Table I.

Manganese Steel of 1.20 to 1.60 per cent.

The use of this steel for castings requiring a combination of high strength and high ductility has increased greatly in recent years. Hall[4] has done a considerable amount of work in the development of this type of steel, and has at various times published representative physical properties of the material. Data show that the effect of tempering at approximately 680 deg. C. is to increase the ductility and impart values but to decrease the yield point and tensile strength. The physical properties, both with and without tempering, are very satisfactory, and the choice of the treatment is dependent upon the use to which the castings are to be put.

Although by far the greater proportion of manganese-carbon steel is used in the normalised annealed or normalised and tempered condition because of the excellent results secured by these treatments, a considerable increase in the various physical properties may be secured by resorting to a liquid quench. The results obtained by drawing 1-in. by 1-in. by 6-in. cast-iron test-bars of a typical manganese-carbon heat at various temperatures after an oil quench from 843 deg. C., show that the liquid quench followed by a low tempering produces a marked increase in strength, hardness and endurance limit over the normalised steel, and a decrease in ductility and resistance to shock. As the tempering temperature is increased, a corresponding increase occurs in ductility and shock resistance, with a decrease in strength and hardness and endurance limit.

The data given in the Paper demonstrate what can be expected from cast steel of this type and in conjunction with results of other investigators show its superiority over plain carbon steels in the normalised, annealed and oil-quenched condition.

Steels of 0.35 to 0.45 C and 0.75 to 1.00 per cent. Cr.

Chromium, especially when in combination with nickel, imparts very marked hardening properties to the steel. Therefore, chromium is a very satisfactory alloying element, and most of the alloy castings which are being individually heat-treated to-day contain an appreciable amount of chromium either alone or in combination with other alloying elements. This is due not only to its remarkable hardening and strengthening power but to the fact that its cost is relatively low. Cast steels having a carbon range of 0.35 to 0.45 per cent. and a chromium range of 0.75 to 1.00 per cent. have for a number of years been giving excellent service after suitable heat-treatment for castings where abrasion resistance is required, as in tractor shoes and wearing plates.

In the normalised and tempered condition it develops strength values about equal to the 1.20 to 1.60 per cent. manganese-carbon steel but is not as ductile.

Steels of 0.40 to 0.50 C, 0.75 to 1.00 Cr, 1.00 to 1.50 per cent. Ni.

The addition of a second alloying element to a chrome steel affects the steel not only through the beneficial characteristics of the added alloying element itself, but also because it intensifies the hardening effects of the chromium. Therefore in the rolled steels a large number of steels containing chromium in combination with other alloying elements are manufactured. By far the most important and widely used cast chromium steels are those containing also various percentages of nickel.

A comparison of the results outlined in the Paper shows the superiority of the chrome-nickel steel over the chrome steel under every type of heat-treatment used.

* Extracted from a Paper read before the annual meeting of the American Foundrymen's Association.

† Research Engineer, Sivyer Steel Casting Company.

1 Journal Iron and Steel Institute, "Carnegie Scholarship Memoirs," Vol. V, 1913.

2 "American Society for Testing Materials," Vol. XX, 1920.

3 Gillett and Mack—"Molybdenum, Cerium and Related Alloy Steels," page 37.

4 Trans. A.F.A.—"Manganese in Cast Steels," Vol. XXXIV, page 1152, 1926.

Comparison of Chrome-Nickel and Manganese-Carbon Steels.

The normalised and tempered chrome-nickel steel has slightly higher values for yield point and tensile strength than the normalised manganese-carbon steel, but also has considerably less ductility. Therefore, with the usual foundry heat-treatments, the difference between these steels is not as great as when a more drastic quench is resorted to. The more rapid quenching greatly emphasises the hardening and strengthening effects of the chromium and nickel so that at the higher hardness values the chrome-nickel steel is a better steel. For Charpy impact values of 2.8 and 3.1 foot-pounds respectively, the manganese-carbon and chrome-nickel steels show 64.4 and 84.5 tons per sq. in. tensile strength. Not only does the chrome-nickel steel have greater ductility than the manganese-carbon steel through the top portion of the Brinell range to which it is possible to harden the manganese-carbon steel, but it is capable of being hardened to a much higher Brinell value.

Thus, the manganese-carbon steel is usually used in those cases where moderately high strength values accompanied by excellent ductility are required. The chrome-nickel steel does not show markedly better properties than the less costly manganese-carbon steel when both are given the usual type of foundry heat-treatment.

On the other hand, the distinct advantage of the chrome-nickel steel is that its properties may be improved by proper heat-treatment of individual castings to a far greater degree than is possible with the manganese-carbon steel. In the quenching operation, however, strains are set up by the very rapid cooling action, which may crack the castings before the strain has been relieved by the tempering operation. Therefore, in any castings where quenching is resorted to for development of maximum physical properties the design should be such as to minimise strains. Abrupt changes in section and sharp corners should be avoided in such castings.

Alloy Steels of Exceptional Properties.

Whenever exceptional properties are required in castings of intricate design, a steel having air-hardening properties is desirable. Because of the strains set up by the exceptionally rapid cooling of castings of complicated design or abrupt change in section, it is impossible at times to liquid-quench castings of this type. The element molybdenum imparts marked air-hardening properties, especially when in combination with another hardening element, and is considered as the characteristic constituent of air-hardening cast steels. Its use in recent years has increased rapidly. Molybdenum alloy cast steels are being made in a variety of analyses. A popular one is 0.40 to 0.60 per cent. carbon and 0.25 to 0.35 per cent. molybdenum in combination with chromium.

Although the use of molybdenum in cast steels is increasing, very few data have been published giving physical properties which may be obtained from these steels. The writer has been investigating the properties of various types of molybdenum steels. Although endurance limit tests have not been completed, the results obtained for the other properties show that certain combinations containing molybdenum will develop exceptional values.

As a special representative of this group a chrome-nickel molybdenum-manganese combination has been selected, and Table II gives the properties obtained on each of four heats of this material under five different heat-treatments. The carbon content has a decided influence on the air-hardening properties as shown by the Brinell values when heated to 900 deg. C. for 2 hours, air-quenched and reheated to 370 deg. C.

With a carbon content of 0.34 to 0.42 per cent. an air quench, followed by a 370 deg. C. reheating, produced tensile strength values over 89 tons per sq. in., yield point over 160,000 lbs. per sq. in., and minimum elongation and reduction of area values of 10 per cent. and 28.9 per cent. respectively. Increasing the tempering temperature to 677 deg. C. gave the following minimum for the same carbon range. Yield point, 90,000 lbs. per sq. in.; tensile strength 53.1 tons per sq. in.; elongation, 19.5 per cent.; reduction of area, 40.1 per cent. The impact values are also very high, 20.1 being the minimum.

The hardness data set out in the Paper shows that with reheating to temperatures as high as 540 deg. C. considerable hardness is maintained, even though only an air quench is given. This enables strains to be removed from intricate castings without sacrificing hardness to too great an extent.

Table II.—*Physical Properties of Mn, Cr, Ni, Mo Steel.*

Heat No.	Carbon. Per cent.	Brinell.	Yield point. Lbs. per sq. in.	Tensile strength. Tons per sq. in.	Elongation in 2 in. Per cent.	Reduction of area. Per cent.	Charpy impact. Ft.-lbs.
A—Held at 900 deg. C. two hours; air quenched; 370 deg. C.							
3	0.28	364	145,850	77.6	11.5	30.9	2.6
		364	151,500	78.4	11.5	34.7	2.6
9	0.28	340	112,300	70.9	13.0	41.0	2.3
		340	114,200	71.7	13.5	40.0	10.3
6	0.34	477	174,750	106.2	10.0	30.5	3.1
		477	176,000	108.0	8.5	28.9	3.1
12	0.42	430	160,300	92.0	10.0	31.5	3.1
		430	173,150	91.2	10.0	31.5	2.8
B—Held at 900 deg. C. two hours; air quenched; reheated to 677 deg. C.							
3	0.28	255	90,400	53.3	22.5	53.3	23.3
		255	86,750	52.7	23.0	51.9	22.2
9	0.28	241	81,750	49.9	22.0	51.5	19.0
		241	80,600	49.7	23.0	51.7	17.7
6	0.34	269	90,900	55.1	23.0	51.7	20.1
		269	93,250	55.2	22.5	50.6	21.7
12	0.42	269	91,100	53.2	19.5	40.1	23.8
		269	90,550	53.4	19.5	45.4	23.2
C—Held at 900 deg. C. two hours, air quenched; held at 840 deg. C. two hours, oil quenched; reheated to 677 deg. C.							
3	0.28	255	93,900	53.7	22.5	43.4	22.5
		255	91,000	52.6	21.5	48.1	19.0
9	0.28	255	81,100	50.9	25.0	53.8	25.8
		255	75,850	51.0	24.0	53.3	24.5
6	0.34	269	92,350	56.5	21.5	42.8	23.2
		269	103,500	55.8	17.5	48.6	19.0
12	0.42	269	93,000	54.4	21.5	39.1	20.5
		269	94,500	56.9	17.0	33.7	21.7

Size of test-bar, 1 in. × 1 in. × 6 in.

Comparisons of Physical Properties of Various Steels.

In comparing the results of the typical heats for the various steels outlined, all of which heats have been made in the acid electric furnace and which have received degasifying additions in sufficient quantity to prevent objectionable porosity in green-sand moulds, it has been concluded that (*a*) when normalised at 900 deg. C. and reheated to 690 deg. C., the molybdenum steel has markedly better all-round properties than either the manganese-carbon or chrome-nickel steels. Its superiority is greatest in yield point and Charpy impact values; (*b*) the molybdenum-containing steel has exceptional air-hardening properties. A simple air quench and tempering treatment of the latter steel develops properties equal to and in many instances superior to those obtained by a liquid-quench on the other types; and (*c*) when liquid-quenching is employed, to obtain high hardness values, the molybdenum steel is superior to the chrome-nickel, which in turn is better than the manganese-carbon steel. It has greater hardening possibilities, and for any definite fairly high hardness value has greater toughness and ductility than the chrome-nickel.

Conclusions.

Data have been presented by the author to supplement information contributed by other investigators relating to alloy steels adapted to foundry use. The interest the subject holds for many producers and consumers makes advisable the free interchange and the broad publication of reliable information on the subject, for the benefit of all concerned. The author believes that those who make common or carbon steel castings and those who make special or alloy steel castings will best promote the profitable and otherwise satisfactory distribution of their products only as these producers make generally available, accurate information showing typical properties, and only as these manufacturers, after discriminating consideration, recommend consciously whatever grade of steel, common or alloy, may appear best adapted to the job in hand.

Selection of the steel to be employed involves economics, which is outside the scope of this Paper, except as it may now be touched upon in appropriate closure. The author has indicated that the manufacturing costs of the steels herein described increase in the same relative order as do their physical properties that are regarded as desirable for many severe service conditions, where toughness alone or in conjunction with one or more additional characteristics is highly important. Heat-treatment costs must be considered as well as metal, moulding, and other items of expense incurred prior to the final forming of the casting. Machining costs must not be disregarded, although it should be appreciated by consumers that, generally speaking, as the toughness of a metal is increased, the latter necessarily offers more resistance to many kinds of punishment, to one of which the material is unquestionably subjected when it is machined. Maximum toughness and minimum mechanical effort when machining appear to be incompatible. Modern machine tools have been wisely designed so as to apply great machining force with relatively small noticeable effect on direct finishing expense. The final cost of the casting, influenced greatly by its durability, is the paramount economic consideration.

It seems worth while, in speaking of durability, to mention the all-important fact that in a sense peculiar to the foundry, the chemical composition of the material of which the article is made is by no means conclusive evidence of the serviceability of the manufactured piece. The extent to which this applies becomes greater as one leaves the field of common or carbon steels, and extend the study to the simpler alloy and the more complex alloy steels. A great many details of foundry technique, quite apart from the satisfactory manufacture of the metal in the furnace, are involved in the production of alloy steel castings that will render satisfactory service. Certain alloying elements have

(*Continued on page* 178.)

Testing the Quality of Grey-Iron Test-Pieces.

INTERNATIONAL MEETING QUERIES VALUE OF SMALL TEST-PIECES.

(*Continued from page* 150.)

Mr. J. G. Pearce, continuing his discussion, said that the Paper continued by a logical process of development to impracticable conclusions to which we have been accustomed in previous Papers on this test, with regard to the necessity for small pieces, trepanning, etc. His (Mr. Pearce's) view with regard to the ball-test and micro-examination was perfectly consistent, and he thought of them exactly as he thought of the shear test, as a useful method of examination in investigating a casting for any purpose, but he would not for a moment consider putting the ball test or micro-examination in a commercial specification, any more than he would think of including the shear test. The authors did not dispose of the small test-piece difficulty by quoting Czochralski.

French Shear-Test Specification Analysed.

He would, however, be content to leave the consideration of the value of the new tests to be assessed by the specifications given at the end of the Paper, the first specification which had been available embodying these new tests. The tests are shear, hardness and transverse, with, under certain considerations, the compression test. The number of test-pieces may vary according to the weight of the casting, but is between two and five. Castings under 4 cwt. have two tests and these are both shear tests, but for 3, 4 or 5 test-pieces one is a transverse test. The ball test specified is such that by itself it carries practically no weight at all. Thus for ordinary, strong and extra strong castings the range of Brinell hardness is 130-240, 150-240, and 170-240. The figures given for the other tests are shown in the attached table. They

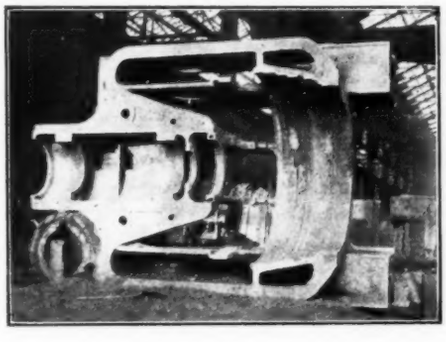


Fig. B.

have been obtained by converting the figures to English measurements and assuming a ratio of shear to tensile of 1.3. In the transverse test, since the load on the bar, only one-eighth of a sq. in. section, tested at 1 in. centres would be meaningless to British readers, the load is expressed as modulus of rupture, which is usually 1.8 to 2 times the tensile. He was not clear whether the transverse test-bar was tested in the upright or the flat positions, but had assumed the case most favourable to the authors, that it was tested flat. In this case the transverse test was rather high compared with the tensile which, incidentally, agreed very well with the compression test. The conclusion drawn from these figures was that as specification figures for extra strong, strong and ordinary castings they are extremely low and would not be acceptable to British engineers. The tensile figures quoted in the French specification would probably require under British conditions, to be, say, 16, 12 and 9 tons per sq. in. A deflection figure of 0.01 in. would seem almost meaningless.

The figures quoted in the specification suggest that they refer to the weakest portions of the casting taken on small bars trepanned from thick sections, thereby tacitly admitting what has so often been criticised as the drawback to the Frémont shear and transverse tests.

	Extra strong.	Strong.	Ordinary.
Tensile—tons/sq. in.	12.2	9.8	7.3
Transverse rupture stress—tons/sq. in.	27.0	22.2	17.3
Deflection—in. ..	0.01	0.01	not specified
Compression—tons/sq. in.	49.6	40.0	30.5
Brinell	170–240	150–240	130–240

Assessing Relative Importances.

Mr. W. Jolley said that MM. Le Thomas and Bois had given a good account of the shear-test method for testing cast iron. Although he did did not fully agree with his views it was realised in this country that the shear-test method was worthy of full examination, and it had been given every consideration before stating that the British did not consider it a satisfactory test for cast iron. Apparently the views of the suppliers of steel castings were the same. M. Le Thomas stated that the transverse test was the best test for cast iron, and ought to take the first place amongst all other tests, yet the specifications in the Paper placed the shear test as first test and suggested a static transverse test if required. Did not the authors consider the transverse test, coupled with the deflection test, to be the best test for giving an indication of the quality of the cast iron? The tensile test appeared to be the most satisfactory for giving an indication of the structure of cast iron. No engineer would consider buying castings on a tensile test only, but they bought castings with a deflection and transverse test. All foundrymen realised they could obtain high tensile tests with low transverse and deflection, also high shear test with low transverse and deflection. The authors considered the tool marks left on the shear-test-core did not vitiate the result. His experience when obtaining shear-test-cores from large castings, especially with portable drilling machines, was the lack of uniformity in the diameters of the specimens, and in some instances a difference of 0.007 had been obtained, necessitating the machining of the test-pieces to 0.22 dia.

Problem of Choice of Location of Tests.

As the authors pointed out, it would seem absurd to judge a casting by its examination of a particular point, but the different points must be sufficiently numerous and judiciously distributed; he would like to ask the authors who would decide these points and what would be the variations allowed in the tests?

Fig. B showed a bottom-half turbine casing. The black spots show the positions from where shear-test-pieces were trepanned.

Table D showed the physical and chemical results of the bars cast separately, also the shear-test results of the trepanned test-pieces that had to be machined owing to the wide variation in the diameter of the test-cores, due to the use of a portable drill and the grinding action of the cuttings.

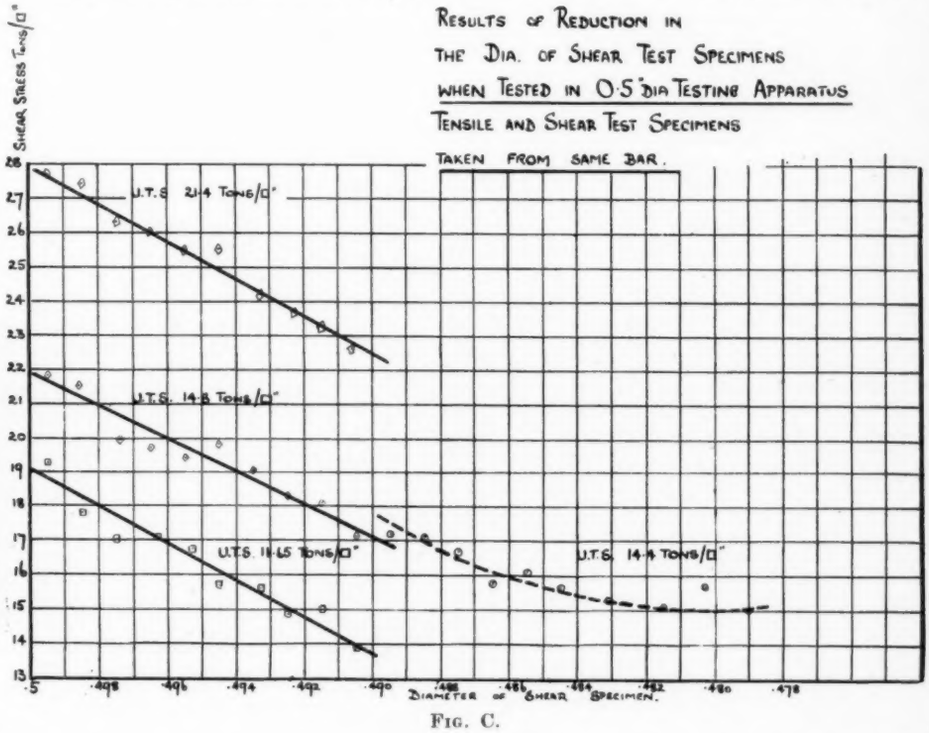

Results of Reduction in
the Dia. of Shear Test Specimens
when Tested in 0.5" Dia Testing Apparatus
Tensile and Shear Test Specimens
taken from same bar.
Shear Stress Tons/□"
U.T.S. 21·4 Tons/□"
U.T.S. 14·8 Tons/□"
U.T.S. 11·65 Tons/□"
U.T.S. 14·4 Tons/□"
Diameter of Shear Specimen.

Fig. C.

Where did the authors suggest, asked Mr. Jolley, the test-piece to be trepanned from in a casting of this description? If there were to be a test-piece for every different section, he was afraid the inspecting engineers would object strongly to the number of plugs required; also, what specification would cover a casting such as this with so many varying sections.

Fig. C showed the results obtained from bars machined to reduced diameters varying by 0.001 in. and tested in the 0.5 in. dia. testing apparatus, published in The Foundry Trade Journal of April 4, 1929. It would be seen that any slight reduction in size from an exact fit in this method of testing was a great factor. An examination of the fractures showed a clear

shear for the bars machined to size, but those under size had a fracture that indicated a bending action had taken place. Did not the author consider that the shear-test-piece as trepanned to be sufficiently accurate enough to be the controlling test for the acceptance of large and intricate castings?

Table D.—*Tests from a Large Turbine Casing on Cast-Off Bars.*

Analysis.

G.C., 2.75; C.C., 0.62; Si, 1.33; Mn, 0.67; S, 0.095 and P, 0.61.

Physical tests. (Bars cast 1¼ in. sq., machined 1 in. sq., tested 12 in. centres.)

Transverse. Lbs.	Tensile. Tons.	Deflection. In.	Brinell.	Shear. Tons.
3,130	14.6	0.128	229	21.4

Shear test. (Bars trepanned from 3-in. and 1¼-in. sections, machined to 0.22 in. dia.)

3-in. section .. .. 14.8 tons.
1¼-in. „ .. .. 17.2 „

Brinell Hardness and Machinability.

Regarding the Brinell hardness-test specification of 170 to 240, had not the authors had the experience that steel mixtures with 250 and over gave castings readily machinable? Owing to the lack of data on this method of testing he did not consider it advisable to introduce it yet in a specification for cast iron.

Table E showed the relationship that had been found to exist between the shear test and tensile tests taken from daily tests over a period of six months. As the same specimens were used for shear and tensile the question of errors in composition and physical condition of castings were eliminated.

Table E.—*Shear Relationship to Tensile.*

Shear 0.22 in. dia.

Bar cast 1 in. square and machined to 0.5 in. dia. tensile, afterwards tensile test bar machined and used for shear tests.

10.5 tons tensile	1.61 ratio	17.0 tons shear.
13.5 „ „	1.47 „	20.0 „ „
16.5 „ „	1.39 „	23.0 „ „
19.4 „ „	1.34 „	26.0 „ „
21.3 „ „	1.31 „	28.0 „ „

Shear 0.5 in. dia.

Bar cast 1 in. square and machined to 0.5 in. dia. tensile, afterwards tensile bar used for shear tests.

9.5 tons tensile	1.84 ratio	17 tons shear.
12.5 „ „	1.60 „	20 „ „
15.5 „ „	1.47 „	23 „ „
18.5 „ „	1.40 „	26 „ „
20.5 „ „	1.37 „	28 „ „

These ratios were from the curves plotted from over 150 tests. From the results it was found that the lowest tensile result 9.5 tons showed a ratio of 1.84 to the shear test, whereas the ratio for the tensile test of 21.3 tons was 1.31. It appeared that the ratio between shear and tensile test was definitely, inversely proportional and was not a constant figure for cast iron.

A curve plotted from over 150 tests showed that it was practically impossible to obtain a line for the transverse tests against shear tests, and if one compared the chemical composition nothing but confusion arose as results were so contradictory. The following were some examples.

Graphite Size and Small Test-Pieces.

Fig. D showed an attempt to demonstrate the results obtained from an 8-in. block of cast iron with a core cast in to allow for varying wall thickness. It would be seen that the wall thicknesses were ⅝ in., ⅞ in., 2¼ in. and 3 in. A 1-in. slab was cut off the bottom of the casting and then shear-test specimens were taken from the eight positions as shown by rings. Two 0.5-in. test-pieces were taken from each wall so as to obtain duplicate tests on each thickness. In the bottom right-hand corner would be seen the analysis of the cast iron which was obtained from drillings taken at various points. In the centre space of the block would be seen the shear-test results, and there was a very noticeable difference between the 3-in. and ⅝-in. sections, although they were both from the same metal and the same casting.

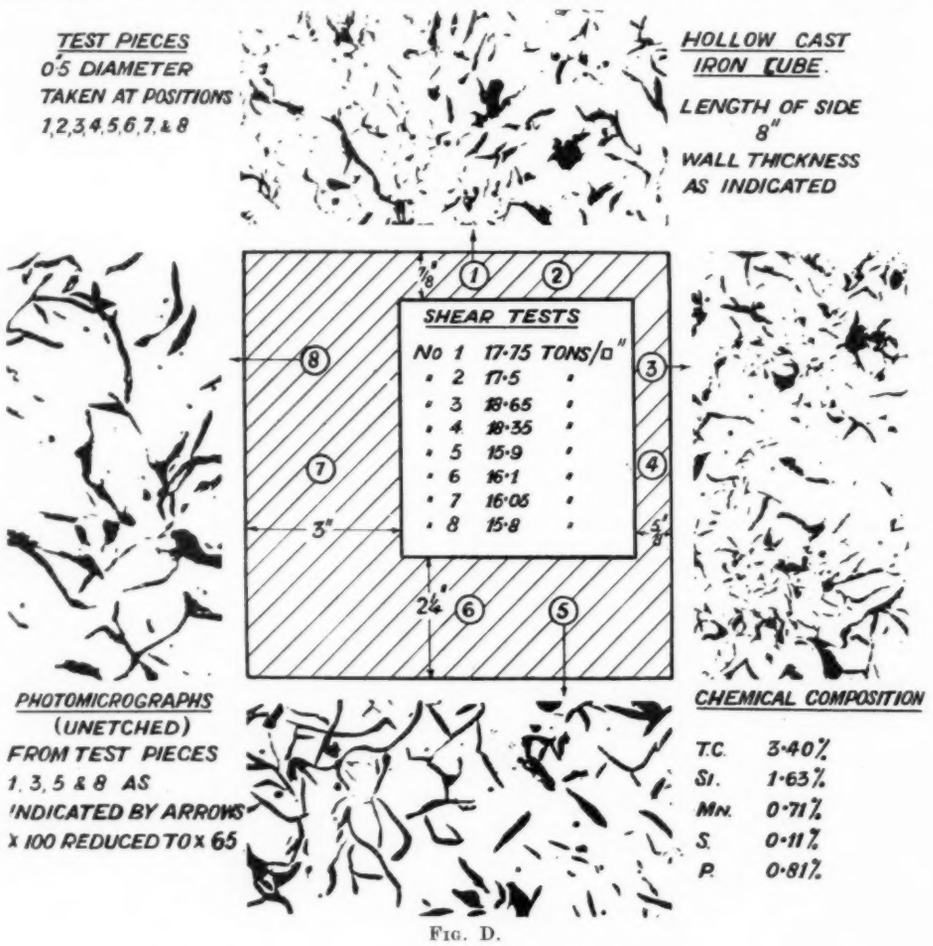


Fig. D.

Round the edge of the block could be seen micrographs showing the size and structure of graphite at the points where the shear-test specimens were taken from. These were self-explanatory, especially when one compared the large flakes in the 3-in. wall with the smaller one in the ⅝-in. wall.

It would probably be of interest to visualise the volume space the graphite flakes would occupy in a 0.22-in. shear-test specimen taken from the 3-in. wall just where the graphite flakes bunched together, and would it be a representative piece for the metal used in the casting?

From the results shown in Fig. D and further tests that had been carried out, it was considered that the position on the casting and section where the test-pieces were taken from would govern the results. To explain the variable results that would be obtained in a casting it would be necessary for all inspectors to be thoroughly familiar with all carbon changes in cast iron due to different section structures which did not appear in steel castings.

No.	0.5-in. shear.	0.22-in. shear.	U.T.S.	Transverse.	C.C.	G.C.	Si.	Mn.	S.	P.
29 ..	18.8	19.1	12.05	2,550	0.58	2.8	1.63	0.76	0.117	0.58
35 ..	18.6	19.1	18.8	2,640	0.58	2.85	1.63	0.72	0.116	0.76
42 ..	24.3	23.8	16.4	3,360	0.58	2.8	1.63	1.25	0.113	0.59
49 ..	17.8	17.8	11.3	2,590	0.57	2.85	1.66	0.77	0.117	0.69
				Block	0.55	2.85	1.63	0.71	0.11	0.81

Where the British Test Fails.

Mr. H. J. Young said the French Frémont test is a genuine attempt to find out what a casting is like. It must be granted that one might need to take a few tests from each complicated casting; it must be granted that in certain castings it would not be practicable to do this. Nevertheless, the Frémont test is, without any doubt whatsoever, a definite and commendable effort to provide a test which will indicate the properties of the iron as it appears in parts of the casting itself. Mr. Jolley had shown a slide of a casting having four sides of very different thicknesses; he could not have chosen any more unfortunate example, because the British test would fail entirely to indicate the properties of that particular casting, whereas the French Frémont test might—and if performed accurately, undoubtedly would—do so.

The President: I had made a note to the same effect myself.

Cast-Off Bars Disparaged.

Mr. Young, continuing, said we needed someone half-way across the Channel to censor the correspondence on this subject passing between the two countries. It should be possible to agree to what the French Frémont test is designed to show; its value and the best manner of carrying it out could come later. If, however, we agree to recognise the main idea behind the Frémont test, it is no less necessary to disclose the same purpose with regard to the British test and to do so in no different spirit. A grave error had crept into our procedure; an error which may

well explain, and certainly excuses, any ill-feeling on the part of our Continental friends. He (Mr. Young) had been a member of the original test-bar committee of this institution, of the next test-bar committee ruled by the British Cast Iron Research Association, of the committee later formed under the auspices of the British Engineering Standards Association. He had followed closely everything said and done by all three committees, and having, for fifteen years, made thousands of separately-cast test-bars, having made hundreds upon hundreds of cast-on bars to Admiralty specifications and those of many classification societies, having likewise—for his own protection and information—invariably cut out test-bars from the casting heads, runners, risers, flanges, and so on of all important castings, he was in a fair position to know the truth. The truth is that *a separately-cast bar does not represent the metal in the casting and is valueless as a comparison of what different works are doing.* For instance, many different qualities of iron will, on a separately-cast test-bar, give 11 tons tensile and 2,500 lbs. transverse (on the Admiralty square bar), but only a few of those many irons will produce any one particular type of casting so that it possesses the desired hardness and strength.

B.E.S.A. Specification Examined.

The one and sole way by which the results from a separately-cast bar can be valuable as a comparison from works to works or as showing the properties of the casting, is when the composition of the metal and the components of the cupola charges are known factors. This is common knowledge which new British Standard Specification ignores and which the Annual Statement of the B.E.S.A. denies. Let us clear up this point and start afresh with our French friends. Clause 2 of our Standard Specification says that "the composition of the iron as cast shall be left to the discretion of the manufacturers, but the maximum percentage of phosphorus may be specified by the engineer or purchaser if he so desires." Clause 5 says that "the engineer or purchaser may also specify cast-on bars where the design of the casting and method of running permit." It is to be noted that the above wording has not by any means the same meaning as if it had said: *The engineer or purchaser may specify cast-off bars where the design of the casting does not permit them to be cast on.* Therefore it is clear that the British Specification not only allows but *inclines towards* separately-cast bars of unknown composition. Let us turn now to the statement of the Tenth Annual Meeting of the British Engineering Standards Association, which, on page 13, reads: "The problem of securing a test-bar *which would accurately represent the mechanical properties of the metal in the casting* has been one of the difficult problems industry has had to face, and this has involved a large amount of experimental work on the part of the British Cast Iron Research Association, to whom the thanks of the Association are due." When the writer, as an active member of those committees, as one who, like many others, willingly gave his time to them, saw that statement he felt the whole thing was spoiled and that we were, in the eyes of the scientific world, no more enlightened, no more wishful for the truth, than before. His (the speaker's) feelings do not matter, but what about those of the French people? They know the meaning of what we suggest in that last statement. They know that the suggestion is misleading and inaccurate. Can we complain, then, if they find themselves unable to accept with great pleasure our criticism of their own attempt to solve a problem which we wrongly claim to have solved by means of our separately-cast bars of unknown composition? Had we not made this unfounded claim the British Standard Specification would have gone down to history as a praiseworthy endeavour to meet the many and diverse interests involved in the commerce of this country, and, moreover, British criticisms of the French test would have come, not from "competitors," but from fellow-seekers after truth.

He (Mr. Young) believes there is no common ground for discussion of British and the Frémont test. In its correct pigeon-hole and properly labelled, the new British Specification is excellent for the use of British founders and engineers as they are to-day; as a solution to the problem of "securing a test-bar which would accurately represent the mechanical properties of the metal in the castings," it is ludicrous. The Frémont test in its present youthful state appears to be just the opposite. He did not think it would suit our engineers and founders of to-day, but, nevertheless, it was a definite step towards securing test-bars which represent the metal in various parts of a casting. It is a very welcome move in the right direction, and he (Mr. Young) has no hesitation in suggesting that had the idea of trepanning test-bars out of the castings been advocated in the first place by a British institution, we should have been "as proud as Punch" about it. It is difficult indeed to see where our claims for it would have ended, considering what we have claimed for the separately-cast test-bars. Let us assess our own test at its true value in order that the French may welcome our efforts to assess the value of theirs, and have sound reason to believe that we are unbiassed and as anxious to learn as to teach.

British and Frémont Tests not Comparable.

He (Mr. Young) said he contributed this criticism of ourselves in order "to bring the war into our own country." He deplored greatly the international acrimony which appeared to have sprung up on this question and which he felt had arisen directly from an atmosphere which ended by inspiring, or permitting to pass uncorrected, that unfortunate statement, as quoted above, of the Tenth Annual Meeting of the B.E.S.A., concerning the new British specification. It was his belief that it was advisable to form an international test-bar committee, composed of those who, having no prejudice on matters scientific, would be as critical of their own and of their own nation's work as that of anyone else or of another nation.

The Polish Attitude.

Mr. Branson (London), speaking on behalf of the Polish Delegation in general and Mr. K. Gierdziejewski in particular, said it was hoped to contribute something to this subject of testing materials in the near future as work was being started in Warsaw. As regards the present discussion, it was felt that it would be very useful in preparing an international standard to introduce a new shock test for cast iron, since the existing shock test, tensile test and shear test did not appear to be very satisfactory. The reason was that certain classes of castings, such as crank cases, had to stand up to continued shocks, and in such cases brittleness was a great disadvantage. It would be an advantage to find a shock test in which the results would be more concordant, notwithstanding the shape of the section, than is now the case. Further, it might be a good thing to do away with the notch in the shock test. It would then be possible to found some relationship between brittleness, bending, etc. This was the point of view the Poles were taking up, because they had found out that shear tests were not satisfactory, and that although tensile tests were very good they also were not altogether satisfactory. Therefore they were intending to try and find a shock test.

Transverse Testing Commended.

Mr. J. E. Fletcher said he took very much the same view of this matter as his confrères. This subject had been thrashed out many times and, after all, the final thing they were all interested in was the obtaining of a good casting. Our French colleagues had, like ourselves, been trying to find a method which would indicate the value of the structure, under varying conditions, of a casting, and he felt that the French were to be congratulated on having brought forward this truly interesting point.

He agreed with Mr. Young that we want something which will enable us to know more of the structural strength of different points in a casting, and several things had been studied by him in connection with the transverse test which many of them thought gave the best criterion as to the strength of the metal used in a casting. Founders must, for example, consider more carefully the ratio between the shear stress and what we call rupture stress or modulus of rupture, which is an estimated value.

In cast iron there was a continually varying ratio between the compressive and the tensile strengths of the material, and he thought the tables in the Papers should be extended so as to express not only the ratio between the estimated rupture stress in the transverse test and the shear stress in the French test but also, in the old-fashioned way of putting it, between the centre breaking load and the shear stress on the standard test-piece or bar. If one examined the work of Frémont and Portevin it would be found that there was a close relationship between transverse deflection and the shear-stress values. It was very difficult to say what these relations should be, but all such parallel comparisons were of great use.

We should look seriously at our transverse-test results, not altogether in the light of a simple estimated rupture stress—which he did not consider was a satisfactory figure at all for cast iron—but in relation to the centre breaking load which was not an estimated but a definite value.

He would not like our French friends to feel that we in this country did not appreciate to the full their attempt to deal with this most difficult problem. As a matter of fact, our appreciation is one of thankfulness for the boldness they had displayed in facing this problem, and he hoped that the Institute would not neglect to show their great appreciation of the splendid work done by M. Portevin and his associates.

Formality Not Yet Reached.

Mr. W. H. Poole expressed the view that the discussion had rather drifted away from the real point at issue. With regard to test-bars, in looking at a large number of results there was a lack of uniformity in them although taken from the same source and produced under the same manufacturing conditions. It was surprising that sound test-bars could be made in the ordinary commercial way. He also agreed with Mr. Young that the shear test has some advantage in enabling us to ascertain something about the internal structure of a casting, although he was afraid that the founders in this country would seriously object, from the casting point of view, to having such tests. It was a difficult thing at times to persuade foundrymen to make as much use of the transverse test as they should on account of the additional cost. Whilst he felt that we had to thank the French for their efforts in this matter, however, his experience of testing work generally in this country led him to agree that our tests were more likely to be useful as a standard of comparison than the shear test. At the same time, he felt we have a long way to go yet before we are likely to devise a means of testing which would give an indication of what is likely to happen under practical conditions in regard to all sections and weights in a manner that would suit everybody.

French Proposals are Tentative.

M. Ronceray said it would be very satisfactory if we could devise some means of ascertaining the quality of the casting itself. Although in France they had suggested the shear test, they would be only too willing to adopt any standard test agreed upon by all the other Associations. The French Association had absolutely no desire to impose their views upon the other nations. They were merely trying to find

what is a good test, and the Paper was an attempt in that direction, without any suggestion that what was suggested should be accepted as final. If anything better was devised and was universally agreed, the French would be delighted to adopt it. The difficulty came through mixing the technical and commercial sides, because that inevitably introduced differences of opinion.

Elastic Materials Present Difficulties.

The President remarked that cast iron is by no means an easy metal to test. One must have a perfect testing machine, and the test specimens must be held therein in absolute alignment if concordant tensile results were to be obtained from the same material. It was possible to take bars which were practically homogeneous and alike one with the other, but when the test figures were received quite different results would be found unless the conditions of testing were as near ideal as possible. Any material which had practically no ductility, or so little ductility as cast iron, was a difficult material to test. In these circumstances he felt that our French colleagues had really done something in an attempt to solve a very difficult problem. They had instituted the shear test with the one desire he believed, of introducing means to enable one to find out what is the relative quality of the metal in a casting. Unfortunately, it is considered by some research workers that for such a test to be trustworthy the bars must of necessity be of so large a diameter that it often meant spoiling the casting. It was not a simple operation to trepan a test-bar of the requisite diameter, and there was always the difficulty of getting an accurately dimensioned specimen. It was necessary, therefore, further to machine the trepanned piece in order to secure a test-bar for the shear test which will afford really reliable test figures. He did not propose to say anything of a controversial nature as to whether a single or double shear test was the better, although he personally favoured the double shear test. In either case, however, the test-pieces should be of accurate dimensions, and the bushes, especially the shearing edges, must be kept up to concert pitch. If the test-bar did not fit as accurately as practicable, it would be impossible to get a true shear.

We in this country—and he believed he could speak also for other nationalities—truly realised that our French colleagues had made an honest attempt to provide a test which would really indicate the qualities of the casting. Certain recommendations had been put forward which we at the moment could not adopt on account of the difficulties that were foreseen, and have now, to a certain extent, been proven, but this fact gave not the slightest reason for any suggestion of hostility. On the contrary, he felt that all other countries should be very thankful to the French for having done such a great amount of pioneer work.

The President then proposed from the Chair that the Congress express its sincere appreciation of the researches of their French colleagues in connection with the proposed shear test. This was carried with acclamation. At the same time the President expressed the hope that complete harmony would exist between the various members in any future discussion of the matter.

Basic Principles Outlined.

Mr. J. E. Hurst wrote that in all these discussions on the methods of testing cast iron it seemed to him that the matter of the definition of the purpose of the application of mechanical tests was involved. Two definitions presented themselves. One might define the purpose of the application of mechanical tests as a means of ascertaining the strength of the metal in the castings, or alternatively as a means of standardising the quality of material which went into the casting. Whilst it is not clearly stated, the French method for which MM. Le Thomas and Bois are sponsors in this French Exchange Paper appears to have for its object a means of ascertaining the strength of the metal in the casting. Naturally, testing applied with this object is confronted with the many practical difficulties which are familiar to all foundrymen, and are amply discussed in the Paper. Furthermore, in order to make some attempt at an adequate realisation of this object, some such special forms of testing did appear to be necessary.

Whether it was desirable for commercial purposes even to attempt to ascertain the strength of the material was another matter. The statement of Pearce, used by the authors, that the design of a casting was based on the strength of the material of which it was composed, used broadly and unqualified, was wrong and misleading. Most generous concessions have to be made in practice on the score of reliability, and the value of any strength determination of the material, however determined, was largely depreciated on this account.

The very first clause in the model specification proposed by the authors covered these sources of unreliability, and, short of testing the casting as a whole under the conditions which it had to sustain and maintain in practice, there was no other method of being absolutely certain as to the reliability of any casting.

However carefully carried out, the commercial value of any mechanical tests of the strength of cast iron in the casting was of little or no use in determining the reliability of the casting, and goes no further than establishing the quality of material of which the casting is made. This brought one to the second definition of the purpose of mechanical testing, *i.e.*, a means of standardising the quality of material which went into the casting. From a commercial point of view, there could be no doubt that the separate test-bar satisfies this object in the simplest possible manner.

This being granted, the logic of the series of test-bars put forward in the B.E.S.A. specification could not be disputed. This matter, however, had received ample consideration in other quarters.

Variation of Tensile Test with Composition.

Dr. A. L. Norbury (British Cast Iron Research Association), referring to the French Exchange Paper, wrote that there were many statements of the authors with which he disagreed, particularly their suggestion that tensile tests on cast iron were unreliable. He had tested several hundreds of grey-iron test-bars in tensile during the past year, and the systematic variation of tensile strength with composition and the close agreement between duplicate results was such as to prove that the test was an accurate and reliable one.

The author referred to some tests he made on round and square transverse bars,* but has mis-read or misunderstood what he had written. The object of the tests was to show that the greater modulus of rupture transverse strength of round bars than square bars was, in the tests in question, entirely due to a difference in the distribution of stresses in the two types, and was not due to a difference in crystallisation at the angles.

Ball Clays.—The term "ball clay" is applied to those plastic "transported" clays which when fired in an oxidising atmosphere to the temperature of some pottery ovens have a white or nearly white colour. The ball clays of the south-west of England provide one of the most important raw materials of the pottery industry. A memoir just issued as Vol. XXXI of the Memoirs of the Geological Survey gives for the first time a complete account of their geological relations, mineral and chemical characters, and of their physical properties. The volume contains numerous analyses and results of physical tests, and a glossary of terms used by the clay miners. Copies at 2s. 6d. each may be obtained from the Stationery Office.

* Bulletin, British Cast Iron Research Association, July, 1928.

Patent Specifications Accepted.

The following list of Patent Specifications accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

6,596. Sprenger Patentverwertung Jirotka, Dr. O., and Jirotka, B. Process for coating metals. 314,769.

9,280. Travis, S., and Callow Rock Lime Company, Limited. Linings for furnaces, kilns, and the like. 314,772.

10,385. Allgemeine Elektricitäts-Ges. Riveting of stay bolts and the like. 289,398.

10,387. Allgemeine Elektricitäts-Ges. Means for working on and repairing boilers, particularly locomotive boilers. 290,272.

10,388. Evans, W. E. (Allgemeine Elektricitäts-Ges.). Locomotives and rolling stock. 315,017.

13,438. Hume, W. R. Machines for bending metal plates or sheets. 315,041.

32,954. Siemens-Schuckertwerke Akt.-Ges. Furnaces for annealing stampings. 308,676.

38,371. Perry, H. W. Railway rails and securing means therefor. 308,677.

119. Vacuumschmelze Ges., and Rohn, W. Process for the production and repair of refractory linings for hearths of metallurgical and other furnaces. 303,417.

16,370. Thomas & Clement, Limited, and Powell, R. Branning and dusting machines for use in the manufacture of metal plates. 315,958.

24,409. Yarrow, H. E. Water-tube boilers and economisers. 316,037.

4,117. Gredt, P. Process for forming briquettes from iron-ore concentrates. 285,040.

4,668. Reinartz, L. F., and Nead, J. H. Process of making commercially-pure iron alloys. 315,444.

7,530. Armstrong, J. J. V. (Badeschin Maschinenfabrik & Eisengiesserei). Cleaning of metal castings. 315,446.

10,637. Browne, V. B. Method of rendering iron-chromium-aluminium alloys ductile. 302,640.

11,396. Collingridge, F. Apparatus for the recovery of metals by electrolysis. 315,481.

15,817. Kolloidchemie Studienges, Carpzow, J. B., March, M., Lenzmann, R., and Sanders, H. Method of deoxidising oxidised metal surfaces, and of protecting metal surfaces against oxidation. 315,531.

9,223. Potts, H. E. (Electro Metallurgical Company). Process of decarburising ferro-alloys. 316,329.

11,705. Kluger, L., and Oesterreichische Schmidtstahlwerke Akt.-Ges. Acid-resisting iron alloys. 316,164.

12,280. Bowen, S. P. Tuyeres for blast furnaces, etc. 316,244.

19,259. Millar, W. S. Process for the treatment of oxide iron ores. 316,404.

20,365. Platt Bros. & Company, Limited, and Jones, A. E. Method of manufacturing bolts and other headed objects. 316,419.

20,370. British Reinforced Concrete Engineering Company, Limited, and Hall, E. B. Metal-reinforcing fabrics for concrete roadway foundations, etc. 316,420.

27,765. Ingham, A. E., and Richards & Company, Limited, G. Machine tools for metal-cutting operations. 316,469.

30,219. Abel, E. Lead-bearing metals containing nickel and copper. 299,773.

35,992. Accumulatoren-Fabrik Akt.-Ges. Process of obtaining pure hydroxides of the heavy metals. 305,092.

37,681. Vanadium Corporation of America. Vanadium alloys. 305,201.

1,168. Krupp Grusonwerk Akt.-Ges., F. Discharge troughs for cooling-beds of rolling-mill installations. 306,478.

5,139. Rhodes, C. J. Presses for sheet metal. 316,514.

21,260. Schrobsdorff, W. Method of producing alloys of very refractory carbides. 276,011.

16,059. Bunet, P. E., and Acieries de Gennevilliers. Induction furnaces. 291,456.

18,818. I. G. Farbenindustrie Akt.-Ges. Manufacture of finely sub-divided metals. 293,749.

19,974. Meeze, A. G. Application of the fractionate combustion principle to the firing of blast furnaces. 316,753.

22,907. Electrolytic Zinc Company of Australasia, Limited. Manufacture of bearing-metal. 295,991.

Vanadium and Titanium in Cast Iron.

By J. E. Hurst.

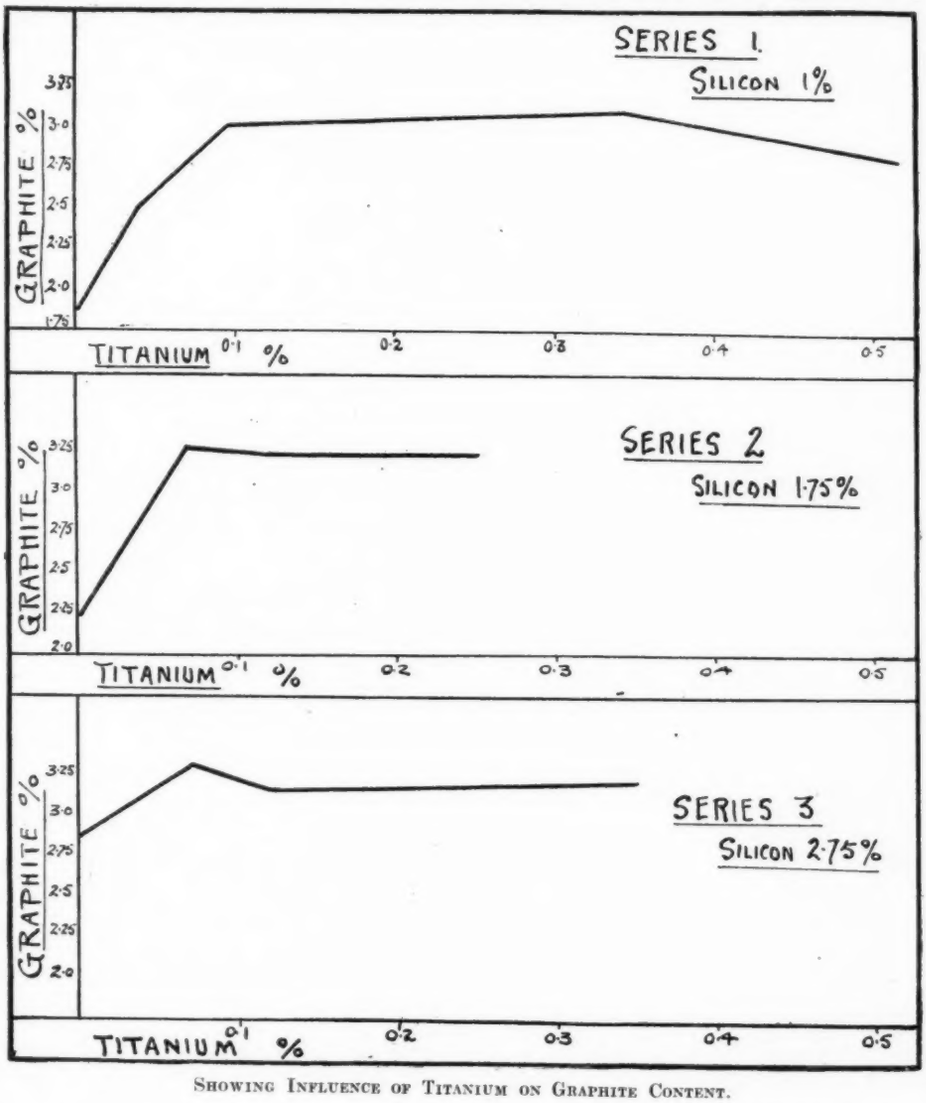
The studies which have been carried out over the past few years into the influence of the addition of various special elements to cast iron have not neglected vanadium and titanium. A review of the investigations of the influence of these elements discloses many interesting and valuable possibilities in their commercial application. The very high cost of making additions of vanadium and titanium by way of their respective ferro-alloys has handicapped severely the commercial development of their use.

Recently, however, the situation has changed, and it has been found possible to manufacture pig-irons containing quantities of both these elements sufficient for general foundry purposes. The comparative cheapness of these irons warrants the attention of the foundry industry being drawn again to the properties of cast iron containing these elements.

Titanium.

Of the two elements, titanium was the first to be discovered, in the year 1761, and the first to attract the attention of metallurgists as an addition to iron and steel. The presence of titanium in the compound shown by Wohler to be titanium cyano-nitride was first discovered by Wollaston, who thought this material, collected in the hearths of blast furnaces, was the metallic titanium. Between the years 1859 to 1861 Mr. Robert Mushet experimented with the addition of this metal to steel, and his "Titanic Steel" was made widely known during this period.

The equilibrium diagram of the system iron-carbon-titanium, has been investigated recently by a Japanese investigator. It has been found that titanium raises the melting point and decreases the amount of carbon in the austenite-cementite eutectic. The amount of 4 per cent. of titanium raises the melting point of the eutectic to approximately 1,180 deg. C. and reduces its carbon content from 4.3 to 3.8 per cent. The solubility of the carbide in the austenite solid solution is likewise reduced. In the alloys containing less than 4 per cent. titanium no new constituent was revealed on micro-examination, and the whole of the titanium was considered to exist in solid solution. Moissan showed that titanium formed carbides, and it is also one of the elements which combines with nitrogen forming a nitride. The compounds of titanium with carbon and nitrogen have been the subject of interest for a long time, and are generally referred to as titanium cyano-nitrides.



Showing Influence of Titanium on Graphite Content.

Titanium itself is a silvery white metal possessing a steely fracture. When cold the metal is brittle, but at red heat it can be forged and drawn readily. It is available for metallurgical purposes in the form of alloys with other metals, such as copper-titanium, manganese-titanium and ferro-titanium. Ferro-titanium and ferro-carbon-titanium are the alloys of interest in iron and steel metallurgy, and are used to limited extent as deoxidisers in steel production.

Titanium in Cast Iron.

Titanium is present in certain pig-irons, and experience has led this to be associated with an exceptional degree of toughness. Hesketh, in recording his experiences in the smelting of this titaniferous iron sands of New Zealand, tells us that the pig-iron obtained and containing titanium is "exceptionally strong—and the castings have a wonderful finish, surpassed by no other iron in his experience." He also records a slight tendency to chill, but this is probably involved in other features which are dealt with below.

The practical experience of this increase in toughness associated with the presence of titanium has led to a number of investigations by research workers in Germany and America from the year 1890 to the present time. The results of these investigations are difficult to compare, and often contradictory. In endeavouring to explain these contradictory results Piwowarsky has drawn attention to a number of factors which appear to have been neglected. For example, a number of investigations have been conducted into the effect of titanium, in which the titanium has been added by means of the commercial ferro-titanium available. This material may have been high in carbon, in which a considerable portion of the titanium may have been present in the form of the nitride or cyano-nitride. In this form it is probable that the titanium may be accompanied by different results. Another feature in many of the investigations is the fact that the effect of titanium has been estimated from the amount of titanium added and not from the amount actually retained in the cast iron. In such circumstances, particularly if rich titanium alloys have been used for making the titanium additions, there is a risk of the titanium being incompletely absorbed by the cast iron, a fact which would lead to discordant results. With these considerations in mind the influence of titanium has been re-investigated by Piwowarsky* in a very carefully conducted series of experiments.

An examination of these results shows that titanium acts very similarly, but more actively than silicon. The addition of up to 1 per cent. or more of titanium is accompanied by definitely improved properties in irons high in silicon. An amount of 0.3 per cent. only was found to improve considerably the properties of low-silicon irons. The influence of titanium on the strength and hardness values of three series of irons of varying silicon content is graphically shows in Figs. 1, 2 and 3. The alloys were made up from a Swedish pig-iron containing 0.15 per cent. manganese, 0.011 per cent. sulphur, and 0.019 per cent. phosphorus. The silicon contents of the three series were arranged at values of 1, 1.75 and 2.75 per cent. respectively, and analysis showed the total carbon contents in each of the three series to vary between the limits of 3.50 per cent. to 4.00 per cent. The improvement in strength values with the addition of titanium is apparent after the titanium has caused the separation of the graphite.

From the microscopical examination of the alloys a noticeable reduction in both the size of

* Stahl und Eisen. Vol. XLIII, pages 1491-1494/1923.

the grains and the graphite particles was observed, even when small quantities of titanium only were present. Piwowarsky observes that this reduction in grain size cannot be attributed to the direct action of the titanium, but rather it is probable that owing to the affinity of titanium for sulphur, oxygen and nitrogen, these impurities are absorbed forming non-metallic compounds. These compounds being insoluble in the iron act as centres about which the crystallisation takes place. Crystallisation thus occurs in a finer network than when the impurities remain in solution in the metal. A summary of these investigations shows that the effect of titanium can be attributed to:—(1) Its effect on the separation of the graphite; (2) the reduction in size of the graphite particles by the titanium, and also probably to (3) the elimination by the titanium of the non-metallic elements dissolved in the iron.

Influence of Titanium on the Formation of Chill.

The graphite forming tendency of titanium, as disclosed by Piwowarsky's researches, is admirably illustrated by the curves given on p. 173. As in the case of silicon, the influence of this element is against the formation of chill. This is confirmed by the experiments made by the Keystone Car Wheel Works, Homestead, U.S.A., and recorded by Dr. Hatfield, in which iron giving a chill-depth of 1½ in. when treated with titanium in the ladle gave a chill depth of 1 per cent. only.

Hesketh referred to an observed tendency of titanium-bearing pig-irons to chill rapidly, and recorded a depth of chill of ⅜ in. in an iron containing 2.5 silicon and 0.04 per cent. sulphur. We are not given any details of the type of casting referred to, and it is not impossible to imagine castings of similar composition and cast under such conditions showing the same amount of chill even in the absence of titanium.

Influence of Titanium in the Production of Malleable Castings.

The influence of titanium additions in the production of malleable castings has been investigated also by Piwowarsky. It was found that such additions promoted the formation of a fine structure in the casting before annealing. In the malleableised casting, the temper carbon was uniformly distributed in a very fine state of division. The dissociation of the carbide was effected more rapidly in the case of titanium treated irons, and the influence of this element was more marked in the case of black heart than in the case of Réaumur castings.

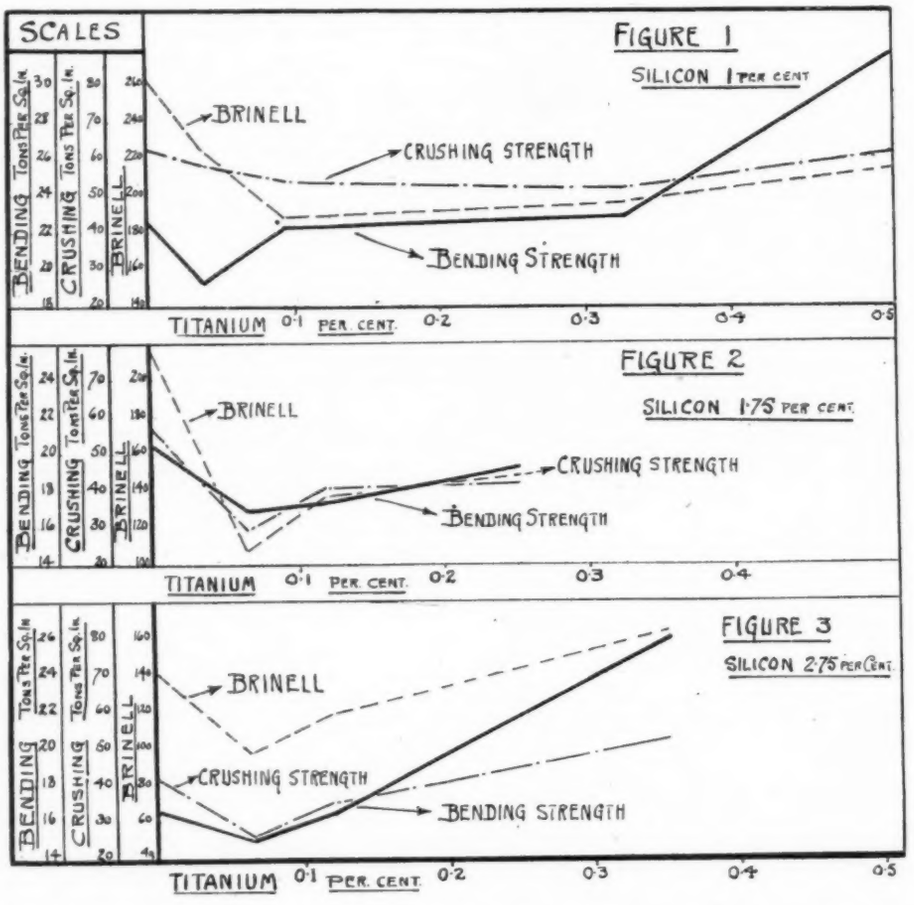
Titanium Addition for Foundry Purposes.

The difficulties associated with the addition of titanium to foundry irons by ways of the ferro-alloys available have been referred to. These difficulties are associated with the high melting-point of the alloys and the possible presence of titanium carbon nitrogen compounds whose influence is still unknown. The readiness with which titanium combines with oxygen is responsible for the large losses incurred when the additions are made in the cupola. Apart from any commercial considerations, there can be no doubt that the most satisfactory way of obtaining titanium additions is by the use of titanium-bearing pig-irons, of which a few are now available.

Vanadium.

This element was first discovered by the Swedish chemist, Sefstrom, in 1830. The metal itself was first isolated by Sir Henry Roscoe in 1867. The metal is greyish-white in appearance, non-magnetic, with a specific gravity of 5.5 at 15 deg. C. and a melting point of 1,680 deg. C. It occurs widely distributed in various rocks, ores and clays in nature, but almost invariably in small quantities. It occurs in the Silesian iron ores, in the Norwegian magnetites and in bauxite clays. Edward Riley in 1864 detected vanadium in pig-iron smelted from the oolitic Wiltshire ores. He found as much as 0.70 per cent., and suggested the use of this iron as a source of vanadium compounds. At one time the principle source of the supply of these compounds was the sandstone deposits at Mottram in Cheshire.

Like titanium, vanadium readily forms compounds with carbon, oxygen and nitrogen. Moissan discovered definite carbides of vanadium. In combination with oxygen it forms a pent-oxide V_2O_5, resembling in constitution the similar phosphorus compound. Many of the vanadium compounds resemble the phosphorus compounds in their constitution. The nitride of vanadium has the formula V.N., and a compound of vanadium and silicon has been claimed to exist containing 47.5 per cent. vanadium and melting at 1,655 deg. C. Vanadium readily alloys with iron entering into solid solution without the formation of chemical compounds. Increasing percentages of vanadium added to iron are accompanied by a reduction in the melting point to a minimum of 1,425 deg. C. (approx.) at percentages of 30 to 35 per cent. vanadium. A 25 per cent. vanadium alloy melts at 1,450 deg. C. and a 40 per cent. alloy at about 1,480 deg. C. The presence of silicon and manganese lower the melting-point still further.



Vanadium Additions to Iron-Carbon Alloys.

The first important record of the addition of vanadium to the iron-carbon alloys is the test made on its influence on armour plate made at the Firminy steelworks, France, in 1896. It was not until the more comprehensive investigations of Professor Arnold in 1900 that vanadium began to receive more widespread attention as an alloying element, and following upon this work vanadium steels have become a definite commercial product. In low percentages, vanadium in steel exists in solid solution in the ferrite, which is stated to be capable of holding 0.6 per cent. in solution. With lower quantities, carbides of different complexities are formed. These have been exhaustively investigated by Arnold and Read.* The investigations into the strength properties of vanadium steels by Guillet showed the best all-round results were obtained with about 0.7 per cent. of vanadium. Norris, writing in "Iron Age," stated that vanadium oxidises readily, but the current view that its use is chiefly or wholly that of a scavenger is a mistaken one. Its value really consists of the fact that even when present in minute quantities it appears to increase the strength, toughness, hardness and resistance to abrasion of the ferrite. Most of the vanadium present, however, is found with the carbide in the pearlite. This carbide is not so mobile as ordinary carbide, does not segregate into large masses, and is more evenly distributed.

Vanadium in Cast Iron.

In the reduction of iron ore in the blast furnace practically the whole of any vanadium present enters the pig-iron. The whole of the experimental work available shows that the vanadium exists along with the carbides in the iron in the form of complex carbides. This has been investigated by Hatfield in this country and Piwowarsky in Germany. The former investigator was able to show that vanadium additions have a definite influence on the physical properties of cast iron, and most other investigators, including Moldenke, Campion, Donaldson and Piwowarsky, find that vanadium increases the tensile, transverse and compressive strengths. Donaldson also states that the wearing properties of cast iron are greatly increased by the presence of vanadium. Table I contains some of the results given by Kent-Smith. Donaldson states that for ordinary work 0.15 per

*J.I.S.I. 1912. No. 1, page 215.

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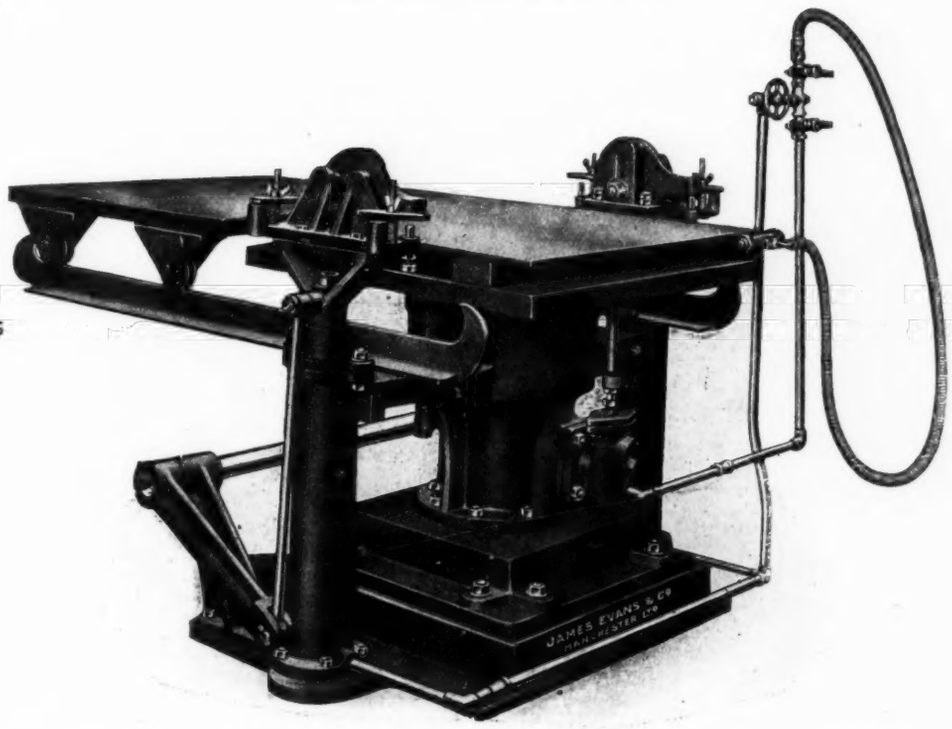

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The above machine illustrates a Jar Ram Machine with Turnover Pattern Plate which can also be used for Stripping Plate Work.

The machine has been designed to combine the two distinct features above mentioned, and is practically two machines in one, equally suitable for steel, iron, etc.

The machine as illustrated is arranged for work that requires turning over, such as steel moulding. And while the turnover arrangements are intended for general repetition work, by detaching the turnover plate from the trunnion brackets the machine can be used for stripping plate work by attaching the stripping plate to the trunnion brackets. Or, on the other hand, by removing the trunnion brackets as well, the table can be used for jolting general jobbing work.

A very important feature of the machine is the simplicity with which the intensity of the Jolt can be regulated when the operator has become accustomed to the use of the machine, which takes but an hour or so. The valves all being on the exterior of the machine are easily accessible, and there is an adjustable arrangement that will allow the jolt to be varied between 1¼ in. to below ¼ in. This being done without disturbing any part of the machine.

The machine is supplied with Withdrawal Carriage, Vibrator, and Blow-off Nozzle complete. It is substantially constructed to stand heavy wear and tear, and requires a minimum amount of skill to operate.

Another important feature of the machine is in the arrangement of the hard wood anvil block for receiving the shock. The blocks being carried well down the machine in a specially designed annular chamber give considerable relief to the foundations. It also provides against the possibility of fracturing the jolting table. Pitch pine blocks are also inserted between the foundation plate and the machine bedplate to assist in the relief on the foundations, and these features considerably improve the working advantages of the machine.

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cent. vanadium is sufficient. Tests show that with this amount the tensile strength is raised by 3½ tons per sq. in., and cast iron which failed in transverse test at a load of 1,300 lbs. attained a load in transverse of 2,200 with an addition of 0.135 per cent. vanadium. This improvement in the strength properties with vanadium additions coincides with the increased combined carbon contents, due to the increased stability of the vanadium carbides.

Vanadium in Industrial Cast Iron.

Vanadium exercises a strong effect on the grain of cast iron, causing a more even distribution of the graphite and giving freedom from internal porosities. In the case of chilled castings, the addition of vanadium tends to produce a deeper and stronger chill, less liable to spall and flake. The addition of vanadium to locomotive cylinder castings in America is reported by locomotive cylinder builders to be accompanied by a reduction in the percentage of losses due to waster castings. As a result of tests made by one of the U.S.A. railroads, locomotive cylinders containing vanadium showed only microscopical wear after 200,000 miles running. Cylinders without vanadium additions showed appreciable wear, about $\frac{1}{32}$ per cent. after 100,000 miles' service. Similar results have been reported in the case of large cylinders and liners in internal-combustion engines.

Table I.

Per cent. added.	Tensile without addition. Tons.	Tensile with addition. Tons.	Transverse without addition. Lbs.	Transverse with addition. Lbs.	Compression without addition. Tons.	Compression with addition. Tons.
0.20	10.7	14.25	Cupola	melted	—	—
0.15	11.6	16.50	Air furna	ce melted	—	—
0.15	13.4	16.70	,,	,,	—	—
0.15	Cupola	melted	2,200	1,300	—	—
0.15	,,	,,	1,900	1,400	—	—
0.15	,,	,,	3,400	2,500	—	—
0.13	Air furna	ce melted	4,200	3,700	—	—
0.13	,,	,,	4,400	4,000	—	—
0.26	Cupola	melted	2,900	4,030	—	—
0.15	—	—	—	—	40.0	67.0
0.15	—	—	—	—	65.2	71.5
0.15	Chill	cast	—	—	96.0	112.0

Vanadium-treated cast iron takes a very high finish on machining and tooling, and a very successful application of this element has been found in the case of glass-bottle moulds, blanks and plungers where a high degree of polish is very desirable. It is said that there is less liability of sticking with glass-bottle moulds in vanadium cast iron.

Amount of Vanadium and its Addition to Cast Iron

For ordinary purposes an amount of vanadium to be added to cast iron recommended is about 0.15 per cent. It is generally recommended that the additions should be made by way of ferro-vanadium to the molten metal in the ladle. The ferro-vanadium should be preferably ground to powder, in which form it can be conveniently added to the molten metal as it flows down the cupola spout. Pig-irons are now available containing at least 0.50 per cent. vanadium, together with an approximately similar percentage of titanium. These pig-irons offer a very convenient method and a cheaper method of obtaining vanadium in the castings. They can be used direct in the cupola without loss of vanadium. It is found that the titanium present prevents the loss of vanadium, itself undergoing a loss of about 20 per cent.

The Government of Ontario intends to introduce legislation for the payment of a bonus of 75 cents per ton on all iron smelted from provincial ore. All the ore now used in the Ontario iron and steel plants comes from the United States, but Northern Ontario possesses large deposits of low-grade ore, which, through the Government bonus, may probably be exploited on an economic basis.

Book Review.

Industrial Furnace Technique, by A. Hermansen. Published by Ernest Benn, Limited, Bouverie House, London, E.C.4. Price 25s. net.

On the jacket of this extremely interesting and useful book a silly and rather bumptious claim is set out in the following terms:—"The scientific principles that govern the design and construction of furnaces of every kind are set forth for the first time in this epoch-making treatise by an eminent Swedish engineer." It is for posterity to say what is "epoch-making." Up to now technical literature has invariably been characterised by dignity, and we sincerely deplore the encroachment of the jargon of the cinema into this particular field. We honestly cannot reconcile the above excerpt with the modesty of the author, who says: "I am hoping that this attempt to rationalise furnace technique will be useful, although I am only too conscious of its many shortcomings."

The Introduction is a chronological résumé of the scientific discoveries upon which modern theory and practice are based. A curious slip has presumably crept in on page 11, wherein it is stated "About fifty years after the Siemen's furnaces Hermansen brought forward his recuperator, which has proved reliable in its working besides being adaptable for several purposes. As the experience of *our firm* is largely concerned with the construction of recuperators, it will be dealt with in the present work." The italics are ours, and as no previous reference is made to the existence of any firm, it makes one wonder.

Chapter I—just 4½ pages is devoted to the elementary physical laws underlying the measurement of temperature. The author, without qualification, says that in England "we still use the Fahrenheit scale in technical science." That is only partially true. The trained British metallurgist undoubtedly visualises high temperatures in the Centigrade scale.

Specific heat is dealt with in Chapter II. The author deems it desirable to detail a study on "true specific heat," yet we doubt whether in any question of furnace calculation this is of any greater utility than the normally calculated figure. To our mind, the ascertainment of specific heats and specific gravities at high temperature is of greater importance. Chapter III carries the study to combustion, calorific value and excess of air. Chapter IV (production of high temperatures) is very interesting and makes a number of statements we have not previously encountered in English-language literature (page 41). Apparently they are based on "imaginative experience," by this we mean that observation of process results has demanded and found in the mind of the operator, a statement which is rational and logical.

The object of Chapter V is to outline the characteristics of the fuels available for industry, whilst in Chapter VI carbonisation is dealt with. Herein one feels that the translation is not all that it should be, for instance, low-temperature carbonisation is stated to give a "very loose coke." The author is obviously very much at home when he deals with gas producers (Chapter VII), whilst the mathematical treatment of transmission of heat (Chapter VIII) is of more than usual interest. Here, again, we would call attention to the translation of chamotte as firebricks, surely it should be either ganister or fireclay. The mathematical treatment of heat transmission is extended, in Chapter IX, to embrace the time factor, whilst a long chapter (X) is devoted to the movement of gases.

Actual practice is detailed in the section covering furnace building in general. The author has decided to adhere to the metric system throughout, and, to our mind, some of the value of the book is lost thereby. For instance, the following may contain much practical information, if one feels disposed to do a little arithmetic, "using artificial draught it is not advisable to go above 90 to 100 kg. of coal per m^3 of the cross-sectional area corresponding to 1.11 to 1.00 dm^2 per kg. of coal per hour or 155 to 140 dm^2 per million calories per hour."

We were interested in a statement on page 158, "we can replace the tar-content by letting the tar or pitch in molten condition drip into the flame," as this recalled to our mind a Patent which was granted to us about 20 years covering this particular phase. An extension of this idea of drip (for the purpose of preheating combustion air) is described and illustrated on page 162. The reviewer's Patent and an analogous one by Mr. Victor Stobie were more concerned with the control of atmosphere in the combustion chamber to avoid oxidation of metallic surfaces.

We are in total disagreement with the author's views on powdered coal for metallurgical furnaces. Excepting cement kilns and boilers, he believes "it would not be desirable to introduce powdered-coal firing in other branches of furnace work as long as good solid fuel is obtainable at a fair price." Cost figures recently to hand exhibit conditions of efficiency much in advance of previous good practice.

In Chapter XII (about 40 pages) is to be found the best section of the book. One can see the *raison d'être* of the previous mathematical treatment by its application to design. This is followed by a study of burners and draft openings, whilst "Working Chambers" (Chapter XIV) contains a quantity of useful practical information. The caption of Chapter XV, "Calculation of the laboratory working space," is probably a too-literal translation. We are cognisant of the French word "laboratoire," and, without reference to any dictionary, we insist that the correct translation is "furnace proper." It might be well to incorporate the word laboratory in our technique for this meaning. Again, in the next chapter, chromite or chrome-iron ore is designated iron chrome. As text books are available on the subject of refractories, we think this section (Chapter XVI) could be deleted without detracting from the value of the book.

In Chapter XVIII, "Starting up and tending the furnace" is not a suitable title, the word "the" requiring qualification for the sake of clarity. "The," in this case, means "the recuperative." Obviously, the technique of this work differs with the various types of plant used.

The last chapter is devoted to "Heat balance" and is a very thoughtful study of a really complicated problem. The book contains 293 pages and 93 illustrations. We suggest that in the next edition an index will be provided.

Messrs. Bell's Asbestos and Engineering Supplies, Limited, announce that they have transferred their head office to their works at Slough. All communications hitherto sent to Asbestos House, Southwark Street, London, S.E.1, should henceforward be addressed to Bestobell Works, Slough, Bucks. The telegraphic address is "Bestobell, Slough," and the telephone number, Slough 830.

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A Survey of the South African Foundry Industry.

Some months ago Dr. Vernon Bosman, Chemical Engineer, Board of Trade and Industries (South Africa), paid a series of visits to Transvaal engineering works, and made a careful study of the conditions under which the industry is operating and the possibilities of expansion. This work has now been consummated by the publication of a report, "The Engineering Industry in South Africa," dated June 20, 1929. Amongst the recommendations put forward by Dr. Bosman are the following:—

(*a*) The position of the present engineering industry requires entire reorganisation, so as to enable it to develop along broader lines. It is strongly recommended that such changes as are necessary should be made in accordance with the industrial Conciliation Act, which supplies all the necessary machinery in matters of this nature. A committee, representing the industry, the Industrial Council, and possibly one or two technical men outside the industry, should be formed to consider each problem in greater detail, and to draw up a tangible scheme for better working conditions.

(*b*) In every industry there are two elements constituting its activities: (*a*) management and (*b*) labour. Each is dependent on the other, and each has its own responsibilities. For either one to disregard the other and work entirely in its own interests is utterly foolish and short-sighted. It is fundamentally important that both these elements work in unison with each other. Labour in any particular industry must appreciate fully the economic factors facing that industry. The nine chief conclusions of Austin and Lloyd, as quoted in this report from the "Secret of High Wages," are fundamental principles in industrial progress, and require careful consideration from both management and labour.

(*c*) It is strongly recommended that the industry be organised in accordance with the discussions set down in this report. A clear and concise definition and classification of the industry should be drawn up and agreed upon. A detailed analysis of the work undertaken by the industry should be made and a clear distinction drawn up between the skilled, semi-skilled and skilled trades.

(*d*) A very strong recommendation is made to the industry to adopt more scientific methods in its foundry. The remarkable progress made by the industries in other parts of the world has been due entirely to scientific research and investigation. "Rule-of-thumb" methods are obsolete and have been discarded where progress is desired. These can only lead to a "mark time" policy, which in the end means retrogression. The local industry must endeavour to keep pace with the rest of the world, and it can only do this by adopting scientific methods. It should be stated, too, that half-hearted attempts in this direction are of little value. The chemical side of the foundry and technical research in methods of mass production are two difficult fields of study, and require the most highly qualified officials. At several points in this report these two facts have been illustrated and emphasised. It is hoped they will receive due consideration from the industry.

No Real Manufacturing.

The industry in the past has done some very excellent work. Judged on its own standards of development and the limited market possibilities, it can be said without exaggeration that the industry as a whole has a proud record to show. Throughout this report a few photographs have been reproduced to illustrate some very excellent jobs which were completed by certain industrial units. This is by no means a complete list of available illustrations of this nature. The photographs were taken at random, and are reproduced here to illustrate the fact that the local industry has done big work, and is capable of bigger. There are several firms who are in a position at present to undertake such work if the opportunity offered.

It must be borne in mind, however, that such records as the industry has to show are the records of the jobbing shop only. A job is undertaken and completed, and it may be months before it returns; an article is manufactured once, and, maybe, never again—these are the conditions under which the greater part of the industry has to strive. It is the most difficult form of shop to organise. There is no standardisation, and, consequently, overheads and labour costs are necessarily high and production small. In industry high labour costs are, to a very large extent, due to a lack of standardisation. As a manufacturing entity, therefore, the industry can hardly be said to exist. It is a development along these lines which offers great scope. But it must be realised that a unit must be either one thing or the other, *i.e.*, either the jobbing shop or a shop designed for manufacturing purposes. A combination of the two can never lead to complete success.

Scientific Control and Research.

In a manufacturing industry, whether it be engineering or any other, there are certain basic principles which never change and which are of extreme importance to the welfare of the industry. Not the least important of these is scientific control and scientific investigation and research. The industrial progress which has been made throughout the world during the last thirty years has been so remarkable and so full of man's ingenuity that only the very technically minded can hope to appreciate it fully. In truth, the rise of industrialism has meant the development of Western civilisation. At the basis of this industrial progress is chemistry and engineering and the scientific method. It is not suggested that each engineering shop should install a chemical laboratory. This would not always be "practical politics." But undoubtedly scientific method should and must be adopted by everyone who wishes to control a manufacturing unit. If data are necessary for the control of the quality or manufacture of a product, whether they be chemical or otherwise, an attempt should be made to procure such data through the correct channels.

Scientific method and investigation is the road which leads to better quality, reduced costs and general industrial progress. It is the road on which industrial countries are pacing and racing along. Unless the local industry follows the example it will soon be left behind. Scientific investigation works slowly but surely, and when finally it shows results, these may be small and not noticeable to the competitor, but they are sufficient to conquer, to bring progress and advancement, and to cause retrogression to those who will not part from the old-fashioned "rule-of-thumb" methods. The best advice to the industry, therefore, is, if it desires a manufacturing unit, to build on the progressive and only lasting foundation of scientific method and research.

Co-operation the Only Way.

Whereas scientific method is the controlling factor in the technical side of a manufacturing industry, it is not likely to increase the size of the market to any extent. Limited market facilities constitute one of the big drawbacks with which the industry in this country has to cope. This difficulty is made more intense by the lack of specialisation in the industry. Each enterprise belonging to the field of general engineering attempts to capture the entire market, and will attempt everything and anything that comes along. The plant consists of all departments of a complete unit, from the foundry to the machine shop, and the foundry may carry as many as 25,000 patterns. Under such conditions it is obvious that a limited market is rendered still smaller. The only way of alleviating this difficulty to any extent is by means of co-operation. In this way it can direct the different jobs into the right channels, and eventually bring about a condition of specialisation which will be to the ultimate benefit of the entire industry. The basis of such co-operation is mutual trust, and its object is service. Without these factors co-operation has never yet succeeded.

Alloy Cast Steels.

(*Continued from page* 168.)

peculiar characteristics that must be taken into consideration in numerous operations essential to casting manufacture. As the production of alloy cast steels increases proportionately in any shop, experience is acquired, having its inevitable and invaluable influence on the satisfactory performance of the product when it is put into service.

Reference made to chemical composition as being no more than one of several important factors makes it appropriate to mention the fact, appreciated by foundrymen but not always understood by consumers, that the behaviour of the metal in a laboratory specimen may be far different from that of the same steel in a member of a casting, due to many possible causes, one of which is design, as determined by the user, and many of which are matters of foundry technique as determined by the maker.

At this time, when the manufacture of alloy cast steels is rapidly increasing, with prospects for extending production yearly, accurate, representative data as to the performance of the many varieties of special steels used for castings are highly desirable. Through no other medium can test results be established as truly representative of the several grades of metal used for the product. The author has attempted to make a contribution for that purpose, with no intention of doing more than showing typical results obtained in one plant. He believes the potential value of his effort, made in the spirit of co-operation, will be chiefly dependent on the stimulating effect it might help to exert on other steel foundrymen to publish information on this subject, following an example for which the author claims no orginality.

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MANSFIELD STANDARD SANDS for CASTINGS in IRON, BRASS & ALUMINIUM

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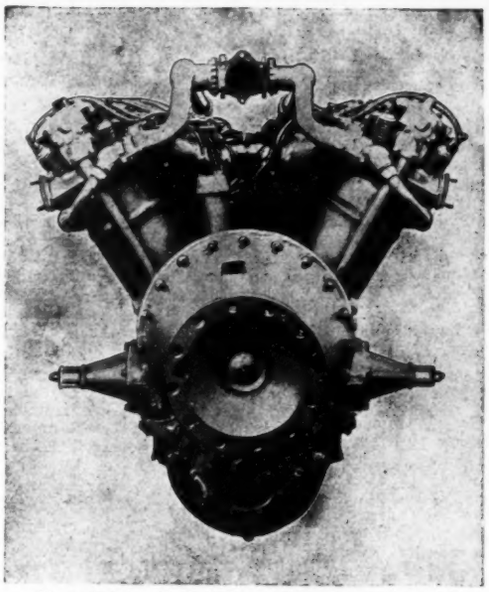

The Rolls-Royce Standard Condor IIIA Engine, as used on British Airship, R100. Aluminium Alloy Castings include crankcase, gearbox, auxiliary drive casing, carburettor and pistons. The main bearing caps are of forged duralumin.

take a leaf out of the aircraft designer's book, —— choose **Aluminium** alloys for strength with lightness.

Data on Casting Alloys gratis from—

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Trade Talk.

MESSRS. BABCOCK & WILCOX, LIMITED, are reported to have purchased 49 per cent. of the shares in a leading Polish boiler works.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, have obtained an order from the Egyptian State Railways for twenty locomotives.

MESSRS. JOSEPH L. THOMPSON & SONS, LIMITED, Sunderland, have received an order to build a vessel of 6,500 tons for Messrs. Headlam & Son, of Whitby.

THE CONSETT IRON COMPANY, LIMITED, shut down their No. 5 blast furnace recently. In its place No. 8 furnace, which is of larger capacity, is to be started shortly.

IT IS STATED that the work in connection with the North-West of England Electricity Scheme, under the Central Electricity Board, will be commenced in the course of a month.

THE FIRM of Richard Melhuish & Company, Limited, tool and machinery merchants, has been acquired by Messrs. Robert Kelly & Sons, Limited, of Liverpool and Manchester.

MESSRS. HUMPHREYS & GLASGOW, LIMITED, in order to secure larger office and laboratory accommodation, have removed to Humglas House, corner of Carlisle Place and France Street, Victoria, London, S.W.1.

THE ANGLO-SAXON PETROLEUM COMPANY, LIMITED, London, have placed with Messrs. Bow, McLachlan & Company, Limited, shipbuilders, Paisley, an order for a single-screw motor-propelled oil tanker, intended for service on the coast of Finland.

THE STEAMER, "Vale of Mowbray," arrived in Grangemouth Docks at 5 a.m. recently with 2,400 tons of iron ore. Discharge was commenced immediately, and by 5 p.m. the following evening the job was completed. The total number of hours worked was 17½.

A TERRIBLE ACCIDENT occurred at the galvanising works of Messrs. Smith & M'Lean, Limited, Mavisbank, Glasgow, when Andrew Walters fell into a tank of molten metal. He was got out almost immediately, but his body and legs were in a shocking state. On arrival at the Western Infirmary it was stated that he was in a very serious condition.

A SERIOUS OUTBREAK of fire occurred in the pattern store of Messrs. Rankin & Blackmore, Limited, Eagle Foundry, Greenock, recently. A large three-storeyed building of reinforced concrete filled with wooden patterns burned furiously for some hours. The firemen succeeded in preventing the fire spreading to adjacent buildings, but damage to the extent of several thousand pounds was done.

THE DUKE OF NORTHUMBERLAND will open the tenth Shipping, Engineering and Machinery Exhibition at Olympia on September 12. The Exhibition will be open for 16 days. The firms exhibiting will number about 250, and numerous engineering organisations have arranged to pay official visits. The chairman of the honorary committee of experts for the Exhibition is Professor H. S. Hele-Shaw, and its general manager is Mr. F. W. Bridges.

INDUSTRIAL ADMINISTRATION methods in this country are attracting world-wide attention, and representatives from Finland, India, South Africa, France, Estonia and Mexico, among others, are paying a special visit to Balliol College, Oxford, next month to attend the tenth annual conference on industrial personnel and welfare management, organised by the Industrial Welfare Society. The Conference takes place from September 13 to 17.

THE PRIME MINISTER received, on August 28, a deputation representing the trade unions connected with the engineering and shipbuilding trades on Tyneside, who placed before him a number of matters affecting the employment situation in that area. The deputation asked that special consideration should be given to this area in the working out of the plans the Government had in hand for dealing with the general unemployment problem. The Prime Minister promised to give careful consideration to the points raised.

CONSTANTINE TECHNICAL COLLEGE, Middlesbrough, is to be opened to students on September 16. Provision for day and evening students is made in the College, which has cost £80,000 to build and about £45,000 to equip. In the heavy metallurgy laboratory are a high-frequency electric melting furnace and an experimental rolling mill. A special course is provided for iron and steel operatives. It is designed for operatives in iron and steel works who do not wish to take the higher courses in metallurgy, but who wish to gain an intelligent interest in their work.

A FEATURE of interest in connection with the electrification of the Manchester, South Junction and Altrincham Railway, contracts for which have recently been awarded, is that the overhead contact wire system at 1,500 volts d.c. has been adopted. This is the first railway electrification to be carried out in Great Britain at this voltage. The British Thomson-Houston Company, Limited, Rugby, has been given the order for the complete sub-station plant, comprising switchgear, transformers, rotary converters and control equipment.

WHETHER there will be brisk times in Clyde shipyards during the approaching winter is a question not easy to answer at the moment. Orders of an important nature are not plentiful, although a number of the yards were given contracts during August, and the uncertainty of costs may be a factor which is keeping back the wished-for flood of orders. Launches during the month were 17 vessels of 48,414 tons. Since the New Year there have been sent down the ways 149 vessels aggregating 372,363 tons, compared with a gross output of 416,203 tons a year ago.

THE TORPEDO BOAT DESTROYER "Van Galen," built for the Royal Netherlands Navy by the Fijenoord Company, to the designs of Messrs. Yarrow & Company, Limited, Glasgow, has completed successful trials on the Clyde. The vessel is the fifth of eight destroyers building in Holland to the designs and under the supervision and technical advice of Messrs. Yarrow. The "Van Galen" is distinguished by the highest steam pressure of any destroyer yet built. The results of the trial prove the advantage of higher pressure and temperature in marine installations, and confirm the economy so significantly demonstrated in recent liners fitted with Yarrow high pressure boilers.

SHAREHOLDERS IN Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, are being notified that certificates can now be exchanged for certificates in the Armstrong, Whitworth Securities Company, Limited. Under the provisions of the scheme of arrangement which was sanctioned by the High Court in March last, holders of preference and ordinary shares are entitled to receive for their present holdings 1s. "A" ordinary shares in the new company, on the basis of 15 new 1s. ordinary shares for each £5 4 per cent. cumulative preference share, one ordinary share for each £1 5 per cent. non-cumulative second preference share, one ordinary for each £1 6 per cent. non-cumulative third preference share, and one 1s ordinary share for every two £1 ordinary shares.

Contracts Open.

Bude, Cornwall, September 19.—2½ miles of 7-in. cast-iron water main, for the Stratton and Bude Urban District Council. Mr. Gower Pimm, 72, Queen Square, Bristol. (Fee £5, returnable.)

Caldicott, Mon, September 13.—3,400 yds. of 2-in. steel water main and 930 yds. of 1¼-in. branches, etc., for the Chepstow Rural District Council. Mr. H. J. Ward, Union Offices, Chepstow. (Fee £2 2s., returnable.)

Listowel, Ireland, September 10.—3½ miles of cast-iron water mains, for the Urban District Council. Mrs. A. Gleeson, town clerk, Listowel. (Fee £7 7s., returnable.)

London, E.C., September 18.—Cast-iron pipes and specials, for the Metropolitan Water Board. The Chief Engineer, 173, Rosebery Avenue, E.C.1.

Newbury, September 6.—100 tons of 4-in. cast-iron pipes, spigot and socket, for the Corporation. Mr. S. Widdicombe, town clerk, Municipal Buildings, Newbury.

Smethwick, September 10. — Boilers, pumps, motors, piping, etc., for the Estates Committee. Mr. R. Fletcher, borough engineer and surveyor, Council House, Smethwick. (Fee £5, returnable.)

Applications for Trade Marks.

The following list of applications to register trade marks is extracted from the "Trade Marks Journal":—

"PROMAL."—Heat-treated ferrous metals. Link-Belt Company, c/o Lloyd Wise & Company, 10, New Court, Lincoln's Inn, London, W.C.2.

"FERSIL."—Alloys of iron and silicon for use in welding. Alloy Welding Processes, Limited, Ferry Lane Works, Forest Road, London, E.17.

"AEROMINIUM."—Metals. C. W. St. John Rowlandson and C. J. Grist, 50, Summer Row, Birmingham.

Personal.

MR. H. B. ROBIN ROWELL has been elected a director of Messrs. R. & W. Hawthorn, Leslie & Company, Limited, Newcastle-upon-Tyne.

MR. J. F. BAKER has been appointed European sales manager of the Westinghouse Electric International Company, 2, Norfolk Street, Strand, London, W.C.2.

MR. M. H. GROSSMAN, research metallurgist of the Central Alloy Steel Corporation, of Massillon, Ohio, is visiting Europe to study special steels, which his company is preparing to manufacture.

MR. J. T. LINCOLN, president of the Lincoln Electric Company, of Cleveland, Ohio, has arrived in London for the purpose of demonstrating the Electronic Tornado process of carbon arc welding at the works of Messrs. Allen Liversidge & Company, Limited.

WE ARE PLEASED to announce that Major J. W. Athey, managing director of the Fordath Engineering Company, Limited, Hamblet Works, West Bromwich, who has been confined to bed for the past six weeks, seriously ill with septic pneumonia, is now recovering.

Wills.

GRAY, THOMAS, of Glasgow, iron merchant £12,596

DARBY, W., of Edgbaston, Birmingham, iron and steel merchant £36,583

BOOTH, J., of Penistone, a director of the Hepworth Iron Company, Limited £4,973

KENYON, T., of Newcastle-upon-Tyne, for 30 years manager of the ordnance and marine engineering departments of Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited £7,426

MOODY, C., of Linthorpe, Middlesbrough, general manager of the Newport and Britannia Ironworks of Messrs. Dorman, Long & Company, Limited, and a former President of the Iron and Steel Trades Employers' Association £10,022

Company News.

Brightside Foundry and Engineering Company, Limited.—Presiding at the annual meeting of the Brightside Foundry and Engineering Company, Limited, held at Sheffield recently, Mr. F. W. FIRTH (chairman and joint managing director) said that in spite of difficult times the profits had increased, and the board had decided to recommend a dividend of 5 per cent., less tax. The company was still fighting keen competition, both at home and abroad, which compelled them to accept orders at very low prices. The installation of further special plant had helped to reduce costs. Present conditions at home had made it necessary for them to go farther afield for their work, and contracts had been carried out in Germany, Holland, Spain, and Australia.

Obituary.

MR. ARTHUR FARQUHAR, engineer, of the Bucksburn Engineering Works, Aberdeen, has died at the age of 52.

MR. JOSEPH DUNN, managing director of Messrs. Clelands (Ship Repairers), Limited, engineers and ship-repairers, of Willington Quay-on-Tyne, died on August 27 at North Shields.

MR. WILLIAM LAWLEY, ironfounder, of West Bromwich, died on August 24, aged 85. Mr. Lawley and his brother, the late Mr. Joseph Lawley, founded the business of W. & J. Lawley, Limited, in 1881.

PETER M'CONNELL, of Glasgow, was fatally injured whilst working in the Strathclyde Foundry of Messrs. G. M. Hay & Company, Limited, Bridgeton, Glasgow. He was assisting in the removal of the core from a large casting, and while trying to dislodge the lining wall with a hammer the wall fell on him and he was buried inside the casting. He was removed in an unconscious condition, and died in the ambulance on the way to the infirmary.

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BRAMCOTE SAND

THE FINEST BRITISH IRONFOUNDERS' SAND

"Small Sands the Mountains,
Moments make the Years"

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FINEST CASTINGS

Unrivalled for its Bond
Perfect in its Silkiness—
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SHEFFIELD

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—September's opening of markets for Cleveland iron has, so far, marked a rather more animated interest with a view to forthcoming autumn demands, which are anticipated to be largely in excess of those recorded in recent years. In the meantime, there is no lack of confidence among the producers regarding the disposal of the output to the end of the year. There is no longer serious competition from the Midlands, where the ironmasters appear to be well sold, and foreign competition—at least in the home market—is negligible. There will, however, be very little foundry pig-iron for sale in Cleveland for nearly a month to come, and by that time autumn buying should be in full swing. On the export side a slightly better return is expected in the August shipments, some fairly heavy tonnages having been booked of late to foreign destinations. Prices remain stable, uniform quotations to home and foreign buyers being :—No. 1 Cleveland foundry iron, 75s.; No. 3 G.M.B., 72s. 6d.; No. 4 foundry iron, 71s. 6d.; No. 4 forge iron, 71s. per ton.

Transactions in the market for East-Coast hematite reflect little change in the conditions, either as regards business generally, or prices, makers still readily disposing of their entire production without difficulty. But quotations are still very unsatisfactory, and when running contracts for raw material expire and ironmasters have to pay current rates, they will be compelled either to advance hematite prices or to face further losses. Consequently the quotation for mixed numbers remains firm at 76s. per ton, with 6d. extra for No. 1 quality. On the West Coast, Bessemer mixed numbers are still quoted at 75s. per ton, f.o.t. at works.

LANCASHIRE.—Resumption of work in the local foundries following the holiday break has now become fairly general throughout the district, and though many consumers are not in a position to see very far ahead, there is no reason to anticipate a falling-off in the rate at which pig-iron has been going into consumption during the past few months. Quotations remain firm as follow : Derbyshire No. 3, 74s. 6d.; Staffordshire No. 3, 75s. 6d., with Scottish brands at from 93s. to 93s. 6d. per ton, delivered equal Manchester.

THE MIDLANDS.—Buying in local markets for foundry pig-iron continues on a restricted scale, and little improvement in these conditions may be anticipated until the autumn is further advanced. Meanwhile, the furnaces report that pig-iron is being taken into consumption at a very good rate, and in some directions the demand is greater than the supply. The minimum zone prices are being quoted, namely, 72s. 6d. for Northants No. 3, 76s. for Derbyshire No. 3, and 77s. for North Staffs No. 3, delivered to local stations.

SCOTLAND.—There is very little business passing in pig-iron in this market. In many cases the founders have already contracted for their requirements, and any inquiries which do come into the market are only for small quantities. Notwithstanding this the price of Scotch pig-iron remains firm on the basis of 76s. for No. 3 foundry f.o.t. furnaces, and some of the makers would like to ask for higher figures.

Finished Iron.

As indicated previously, the demand for Staffordshire marked bars is up to a moderately good level, and considerable business is developing. The price is £12 per ton at works. With regard to crown iron, conditions do not suggest any improvement, and business of any note is entirely absent at the present time. Staffordshire crown bars are quoted at £10, but certain makes are at £10 5s. per ton. Crown iron from outside this area is offered at £9 15s. and upwards. Nut and bolt iron is quoted at £9 5s., but there is no business moving. The reason for this is the continued low price prevailing for Belgian bars, which are quoted at £6 16s. to £6 17s. 6d. per ton delivered to works in this area.

Steel.

A rather more optimistic view of the steel position is disclosed in recent reports, and at Sheffield the market, although still on the quiet side, is very firm. In billets Continental competition shows a tendency to increase somewhat, but the demand for home-produced basic billets continues to expand. Acid steel billets are in small demand, and numerous acid steel furnaces in this district are idle. There is a fairly heavy business passing in wire rods. Quotations :—Basic billets, soft, £7 per ton; semi-hard, £7 12s. 6d.; medium, £8 2s. 6d.; hard, £9 2s. 6d. to £9 12s. 6d.; Siemens acid, £9 10s.; basic wire rods, soft, £8 10s. per ton; medium hard, £9 10s. to £10; hard, £10 15s.; acid, £12 5s. to £12 10s. In the tinplate market quotations are firm at 18s. 3d. to 18s. 6d. basis for coke quality, net cash, f.o.b. Wales.

Scrap.

Markets for foundry scrap material in most cases indicate a return to more active conditions, and on Tees-side ordinary heavy cast iron ' is a little stronger at 67s. per ton, which represents a rise of 6d. per ton, but no more than 68s. 6d. is obtainable for good machinery quality in handy pieces. In the Midlands, there is a slightly better demand for cast-iron scrap, 70s. being offered for machinery scrap in cupola sizes, 65s. for medium heavy cast iron, and 60s. for light metal. In Scotland, ordinary heavy cast-iron scrap, suitable for steelworks, is quoted at 62s. 6d., and for the same quality for foundry cupolas 64s. to 65s.; machinery cast-iron scrap, 67s. 6d. to 70s.; old cast-iron railway chairs, 67s. to 68s., and light cast iron at 60s. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—A more active tendency in dealings in warrant copper has developed recently, and market views generally express confidence in the outlook for the near future. Demand from home consumers has been moderate, although there are indications of an improvement in this respect. Reports from America indicate the probability of increased consumption there, and it is believed that the price of electro will at least be maintained.

Closing quotations are :—

Cash.—Thursday, £73 17s. 6d. to £74; Friday, £74 10s. to £74 12s. 6d.; Monday, £75 2s. 6d. to £75 5s.; Tuesday, £75 11s. 3d. to £75 12s. 6d.; Wednesday, £78 17s. 6d. to £78 18s. 9d.

Three Months. — Thursday, £74 15s. to £74 16s. 3d.; Friday, £75 5s. to £75 7s. 6d.; Monday, £75 18s. 9d. to £76; Tuesday, £76 7s. 6d. to £76 8s. 9d.; Wednesday, £79 18s. 9d. to £80.

Tin.—Movements in the market for standard tin also point to more confident anticipations shortly, and though some slight weakening of values was recorded at last week's close, quotations may still be called firm on the whole. The most recent American advices estimate that deliveries in August are as much as 3,000 tons, or well in excess of early anticipations. There appears to be some uncertainty about European figures and Straits shipments, but it is thought that supplies and deliveries will have about balanced.

Official closing prices :—

Cash.—Thursday, £207 17s. 6d. to £208 2s. 6d.; Friday, £208 15s. to £209; Monday, £206 5s. to £206 10s.; Tuesday, £204 10s. to £204 12s. 6d.; Wednesday, £206 to £206 5s.

Three Months.—Thursday, £212 to £212 2s. 6d.; Friday, £212 5s. to £212 7s. 6d.; Monday, £210 5s. to £210 10s.; Tuesday, £208 10s. to £208 12s. 6d.; Wednesday, £210 to £210 5s.

Spelter.—The spelter market, in common with the other metals, has been quiet, and prices have fallen slightly. There is no improvement in the demand from consumers in this country, whose purchases at the moment represent a small aggregate. Sellers have adopted a reserved attitude, as they see little attraction in the present level of prices.

Daily quotations are :—

Ordinary.—Thursday, £24 16s. 3d.; Friday, £24 13s. 9d.; Monday, £24 1s. 3d.; Tuesday, £24 5s.; Wednesday, £24 8s. 9d.

Lead.—The market for soft foreign pig continues dull and uneventful, but buying on a slightly more active scale has indicated also a somewhat firmer tendency in quotations, with an advance of a few shillings, which may probably be followed shortly by a stronger movement in a similar direction.

Prices have been :—

Soft Foreign Prompt.—Thursday, £23 7s. 6d.; Friday, £23 10s.; Monday, £23 10s.; Tuesday, £23 11s. 3d.; Wednesday, £23 12s. 6d.

The English Electric Company, Limited, have received a further order from the Central Electricity Board for two 15,000-k.v.a. 132,000-volt three-phase transformers for the Central Scotland Scheme, for installation at Saltcoats. The two units will each be provided with on-load tap changing equipment.

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Low Ash. Low Sulphur. Low Phosphorus.
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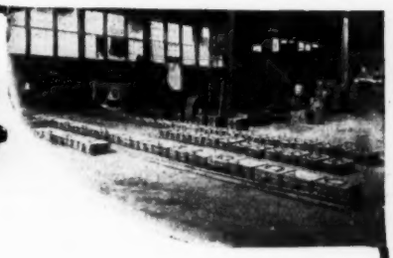

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Lightness and ease of handling, robust construction, accuracy and durability are the paramount essentials of the modern moulding box.

These qualities are solidly built into all STERLING ROLLED STEEL MOULDING BOXES.

They are made to suit your exact requirements, drilled to suit your existing pattern plates, and fitted with bars when required to conform to your patterns.

Many of the largest and most up-to-date foundries in this Country and Abroad are completely equipped with STERLING BOXES.

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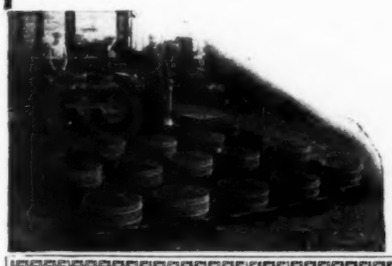

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WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	78 17 6
Three months	79 18 9
Electrolytic	84 12 6
Tough	78 15 0
Best selected	79 0 0
Sheets	110 0 0
India	94 10 0
Wire bars	84 15 0
Do. Sept.	84 12 6
Do. Oct.	84 12 6
Ingot bars	84 12 6
H.C. wire rods	87 0 0
Off. av. cash, August	73 16 8½
Do. 3 mths., August	74 12 2½
Do., Sttlmnt., August	73 16 3½
Do., Electro, August	84 10 0
Do., B.S., August	78 5 10
Aver. spot price, copper, Aug.	73 16 8½
Do. wire bars, August	84 15 0
Solid drawn tubes	15d.
Brazed tubes	15d.
Wire	11½d.

BRASS.

Solid drawn tubes	12¾d.
Brazed tubes	14¾d.
Rods, drawn	12½d.
Rods, extd. or rlld.	8d.
Sheets to 10 w.g.	11¾d.
Wire	11½d.
Rolled metal	10¾d.
Yellow metal rods	8d.
Do. 4 × 4 Squares	8½d.
Do. 4 × 3 Sheets	9d.

TIN.

Standard cash	206 0 0
Three months	210 0 0
English	207 0 0
Bars	206 15 0
Straits	208 10 0
Australian	206 15 0
Eastern	212 15 0
Banca	Nominal
Off. av. cash, August	209 17 11½
Do., 3 mths., August	213 17 6
Do., Sttlmt., August	209 17 7½
Aver. spot, August	209 17 11½

SPELTER.

Ordinary	24 8 9
Remelted	22 10 0
Hard	20 15 0
Electro 99.9	26 15 6
English	24 12 6
India	21 10 0
Zinc dust	(Nom.) 34 10 0
Zinc ashes	8 15 0
Off. aver., August	25 0 7½
Aver., spot, August	24 17 11

LEAD.

Soft foreign ppt.	23 12 6
English	25 0 0
Off. average, August	23 4 5½
Average spot, August	23 3 8½

ZINC SHEETS, &c.

Zinc sheets, English	34 10 0
Do. V.M. ex-whf.	32 12 6
Rods	40 0 0
Boiler plates	30 10 0
Battery plates	31 0 0

ANTIMONY.

Special brands, Eng.	50 5 0
Chinese	32 10 0
Crude	Nominal

QUICKSILVER.

Quicksilver	22 10 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	7 15 0
45/50%	12 0 0
75%	19 10 0
Ferro-vanadium—	
35/50%	12/10 lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/- lb. Mo.
Ferro-titanium—	
23/25% carbonless	11d. lb.
Ferro-phosphorus, 20/25%	£16 0 0
Ferro-tungsten—	
80/85%, c. fr.	3/3½ lb.
Tungsten metal powder—	
98/99%	3/6½ lb.
Ferro-chrome—	
2/4% car.	£32 10 0
4/6% car.	£23 7 0
6/8% car.	£22 12 6
8/10% car.	£22 0 0
Ferro-chrome—	
Max. 2% car.	£33 0 0
Max. 1% car.	£37 12 6
Max. 0·70% car.	£40 10 0
70% carbonless	1/2 lb.
Nickel—99% cubes, or pellets	£175 0 0
Ferro-cobalt	9/4 lb.
Aluminium 98/99%	£95 0 0
Metallic chromium—	
96/98%	2/6 lb.
Ferro-manganese (net)—	
76/80% loose	£13 15 0
76/80% packed	£14 15 0
76/80%, export	£14 0 0
Metallic manganese—	
94/96%, carbonless	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 0
Finished bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	3 15 0	to 3 17 0
Bundled steel and shrngs.	3 12 6	to 3 15 0
Mixed iron and steel	3 10 0	to 3 12 0
Heavy cast iron	2 17 6	
Good machinery for foundries	3 2 6	
Cleveland—		
Heavy steel	3 5 0	
Steel turnings	2 17 6	
Cast iron borings	2 15 0	
Heavy forge	3 17 6	
W.I. piling scrap	3 11 6	
Cast-iron scrap	3 7 0	to 3 8 6
Lancashire—		
Cast-iron scrap	3 2 6	to 3 10 0
Hvy. wrought	3 17 6	
Steel turnings	3 0 0	
Scotland—		
Heavy steel	3 17 6	
Cast-iron borings	2 15 0	
Wrought-iron piling	3 17 6	
Heavy machinery	3 10 0	

London—Merchants' buying prices delivered yard.

Copper (clean)	64 0 0
Brass	42 0 0
Lead (less usual draft)	20 10 0
Tea lead	17 0 0
Zinc	16 10 0
New aluminium cuttings	68 0 0
Braziery copper	56 0 0
Gunmetal	57 0 0
Hollow pewter	155 0 0
Shaped black pewter	110 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	76/6
Hematite M/Nos.	76/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/-
,, d/d Birm.	92/-
Midlands—	
Staffs. common*	—
,, No. 4 forge*	73/-
,, No. 3 fdry*	77/-
Shrops. basic	—
,, Cold blast, ord.	—
,, ,, roll iron	—
Northants forge*	68/6
,, fdry. No. 3*	72/6
Derbyshire forge*	72/-
,, fdry. No. 3*	76/-
,, basic*	—

* d/d Black Country dist.

Scotland—	
Foundry No. 1	78/6
,, No. 3	76/-
Hem. M/Nos.	80/-
Sheffield (d/d district)—	
Derby forge	67/-
,, fdry. No. 3	71/-
Lincs. forge	—
,, fdry. No. 3	74/6
E.C. hematite	87/-
W.C. hematite	87/6
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	74/6
Northants foundry No. 3	—
Dalzell, No 3 (special)	102/6 to 105/-
Summerlee, No. 3	93/-
Glengarnock, No. 3	—
Gartsherrie, No. 3	93/-
Monkland, No. 3	93/-
Shotts, No. 3	93/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.) nom.	10 15 0	
Nut and bolt iron	9 5 0	
Hoops	11 0 0	to 11 10 0
Marked bars (Staffs) f.o.t.	12 0 0	
Gas strip	11 0 0	to 11 10 0
Bolts and nuts, ¾ in. × 4 in.	15 5 0	
Steel—		
Ship plates	8 12 6	to 8 17 6
Boiler plts.	9 12 6	to 10 10 0
Chequer plts.	10 12 6	
Angles	8 2 6	
Tees	9 2 6	
Joists	8 2 6	
Rounds and squares, 3 in. to 5½ in.	9 2 6	
Rounds under 3 in. to ⅜ in. (Untested)	8 0 0	
	and upwards	
Flats, over 5 in. wide and up	8 7 6	
Flats, 5 in. to 1½ in.	7 17 6	
Rails, heavy	8 10 0	
Fishplates	12 10 0	
Hoops (Staffs)	10 0 0	to 10 10 0
Black sheets, 24g.	10 5 0	to 10 10 0
Galv.cor.shts., 24g.	13 5 0	to 13 10 0
Galv. fencing wire 8g. plain	12 0 0	
Billets, soft	6 7 6	to 6 15 0
Billets, hard	7 10 0	to 8 0 0
Sheet bars	6 5 0	
Tin bars	6 5 0	

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6½
Rods	1/5
Tubes	1/9½
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.95
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.50
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplates, 100 lb. box	$5.35

COKE (at ovens).

Welsh foundry	24/- to 27/6
,, furnace	21/- to 24/-
Durham and North.	
,, foundry	22/6
,, furnace	20/6 to 21/6
Midlands, foundry	—
,, furnace	20/- and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/4½
,,	28×20 ,,	37/-
,,	20×10 ,,	26/9
,,	18¾×14 ,,	19/6
C.W.	20×14 ,,	15/3
,,	28×20 ,,	33/6
,,	20×10 ,,	22/6
,,	18¾×14 ,,	16/-
Terneplates	28×20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 10 0
Bars, hammered, basis	£17 10 0 to £18 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 15 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£20 0 0 to £24 0 0
Bars and rods, dead soft, steel	£10 0 0 to £14 0 0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Over ¼ in. up to 6 in.

	Tubes.	*Fittings.*
Gas	65%	47½%
Water	61½%	42½%
Steam	57½%	37½%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Aug.	29 ..	73	17	6	inc.	2/6
,,	30 ..	74	10	0	,,	12/6
Sept.	2 ..	75	2	6	,,	12/6
,,	3 ..	75	11	3	,,	8/9
,,	4 ..	78	17	6	,,	66/3

Electrolytic Copper.

		£	s.	d.		
Aug.	29 ..	84	5	0	No	change
,,	30 ..	84	5	0	,,	,,
Sept.	2 ..	84	5	0	,,	,,
,,	3 ..	84	5	0	,,	,,
,,	4 ..	84	12	6	inc.	7/6

Standard Tin (cash).

		£	s.	d.		
Aug.	29 ..	207	17	6	dec.	2/6
,,	30 ..	208	15	0	inc.	17/6
Sept.	2 ..	206	5	0	dec.	50/–
,,	3 ..	204	10	0	,,	35/–
,,	4 ..	206	0	0	inc.	30/–

Tin (English ingots).

		£	s.	d.		
Aug.	29 ..	208	5	0	dec.	15/–
,,	30 ..	209	5	0	inc.	20/–
Sept.	2 ..	206	15	0	dec.	50/–
,,	3 ..	204	15	0	,,	40/–
,,	4 ..	207	0	0	inc.	45/–

Zinc Sheets (English).

		£	s.	d.		
Aug.	29 ..	34	10	0	No	change
,,	30 ..	34	10	0	,,	,,
Sept.	2 ..	34	10	0	,,	,,
,,	3 ..	34	10	0	,,	,,
,,	4 ..	34	10	0	,,	,,

Spelter (ordinary).

		£	s.	d.		
Aug.	29 ..	24	16	3	No	change
,,	30 ..	24	13	9	dec.	2/6
Sept.	2 ..	24	1	3	,,	12/6
,,	3 ..	24	5	0	inc.	3/9
,,	4 ..	24	8	9	,,	3/9

Lead (English).

		£	s.	d.		
Aug.	29 ..	24	15	0	No	change
,,	30 ..	24	15	0	,,	,,
Sept.	2 ..	25	0	0	inc.	5/–
,,	3 ..	25	0	0	No	change
,,	4 ..	25	0	0	,,	,,

AVERAGE MONTHLY PRICES OF WEST COAST HEMATITE MIXED NUMBERS DELIVERED SHEFFIELD.

Year	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Yearly average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1888	44 4	42 3	42 1½	42 0	41 2½	42 1½	42 6½	44 0	45 8½	44 6	44 6	45 3½	43 4
1889	44 4	45 2	47 3½	48 9½	48 6½	48 7½	50 1½	53 11	55 3	63 6	73 10	73 2	54 4½
1890	76 1½	65 1	63 3	55 1	53 9½	50 11	52 3½	56 4	58 0	58 2	57 5	54 4½	58 5
1891	52 9	50 10	48 11	47 9½	51 5	50 6	50 10	48 4	50 1	49 1½	48 3½	47 8	49 8½
1892	47 4	45 6	46 4½	47 8	49 5	50 4½	49 7½	49 10½	49 10½	48 8½	46 10	46 1½	48 2½
1893	46 0½	45 8	45 11	45 7	44 11	44 9½	44 10	45 3	45 0	44 6	44 7	45 8	45 3
1894	45 3	45 3	45 1½	45 1	43 11	43 11	43 9½	44 2	44 7½	43 7	43 5	43 3	44 3½
1895	42 8	42 5½	42 6	42 10	43 10	43 7½	44 10	45 11	49 11	48 9	47 7½	47 7½	45 2½
1896	47 0	48 9	48 9	48 2½	47 3	47 3	46 10	46 10	47 2	48 5	50 7	50 6	48 1½
1897	51 2	49 10	48 5	47 4	47 9½	48 6	47 0	47 3	47 3	47 0	48 3½	47 11	48 2
1898	48 9	48 10	49 4	49 8½	50 10	50 3½	51 0	52 5	53 11	55 8	57 3	56 10	52 1½
1899	59 1	59 9	57 7	59 6	64 7	70 10½	76 7½	72 2	74 3	75 0	78 1½	73 3	68 5
1900	75 3½	76 10	79 10	84 6	81 4	79 1½	83 4	81 5	79 11	76 10	77 8½	68 4	78 8
1901	60 2	59 0	57 9½	57 6½	57 8	57 4½	57 8	61 0	60 0½	59 9	58 7½	56 7	58 7½
1902	56 1	57 9½	59 3½	59 9	59 10½	60 0	60 0	60 8½	61 5	61 2	59 3	59 0	59 6
1903	58 5	58 8	61 1	59 5	57 10	57 3	56 7	56 3	55 9	54 8	52 4	52 4	56 8½
1904	52 8½	53 1	53 7	54 9	54 2	53 2½	52 9	52 5	52 2½	52 7	53 1	55 11½	53 5½
1905	57 9½	56 9	58 1	58 2	56 4	55 8	55 5½	56 7	61 0	68 9	69 9	70 11½	60 5½
1906	70 4½	65 2½	63 4½	63 9	64 5	64 6	64 1	66 2½	67 3	69 4½	72 4½	78 8½	67 5
1907	77 9	72 11	71 10	73 9	79 9½	76 9	77 9	78 4	75 11	72 9½	68 6	66 7	74 4
1908	62 7	59 1	61 6½	61 6½	61 4	59 1	57 9½	56 11	60 2	59 2	58 5½	57 7	59 7½
1909	51 4	56 5	55 3	56 1	56 4	57 0	56 8	58 0	61 0	61 1½	60 7½	61 4	58 1½
1910	64 0½	64 3½	66 10½	67 6½	66 2½	65 4	64 4½	65 6½	65 2	64 10½	64 6	65 6	65 4½
1911	66 9	66 1	64 10	63 1	62 1	62 0	61 2	62 2	62 1	61 1	61 10	64 0	63 1
1912	67 0	67 0	67 0	69 3	71 9½	72 11	75 9½	79 1½	82 2½	85 0	85 3½	86 6	75 9½
1913	86 6	86 6	86 3	85 0	83 6½	80 10½	78 1	76 10½	72 6	71 0	68 0	65 3	78 4½
1914	64 6	65 4½	65 6	64 11½	64 2½	64 0	64 0	68 11½	74 6½	71 0	65 4½	69 9½	66 10½
1915	78 9	100 6	103 1	113 6	111 9	114 0	116 3	115 2½	113 8½	121 1½	131 9½	139 6½	113 3
1916	135 0	135 0	133 4	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	129 2½
1917	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1918	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1919	127 6	127 6	127 6	127 6	180 6	184 3	195 4½	204 6	204 6	204 6	204 6	204 6	174 7
1920	224 9	235 0	245 0	275 0	290 0	295 0	295 0	295 0	295 0	295 0	295 0	280 0	284 11½
1921	263 4	228 4	180 0	180 0	180 0	160 0	160 0	157 6	142 0	128 6	121 0	115 6	167 9½
1922	125 0	117 6	115 0	115 0	115 0	115 0	113 1½	104 0	105 0	105 0	106 3	110 0	112 1
1923	109 0½	116 5½	133 11½	138 3½	134 2	125 0	115 7½	111 9	110 0	110 0	113 11	115 0	119 5½
1924	115 0	115 0	114 4½	112 6	112 6	112 6	111 0	110 0	110 0	105 4½	102 6	102 6	110 3½
1925	102 6	102 6	100 0	98 6	97 6	95 1½	92 6	90 6	88 3	87 0	88 1½	88 9½	94 3½
1926	90 1½	90 0	89 8½	89 0	89 0	89 0	90 2½	91 9	94 0	97 2½	*	*	91 0
1927	95 4½	95 6	96 6	95 6	95 3	94 0	92 10½	91 6	90 6	90 6	90 6	89 6	93 1½
1928	85 0	85 3	85 5	85 0	85 3	84 9	84 0	83 9	84 0	84 0	83 1	82 6	84 4
1929	82 10½	83 6	85 0	86 9	87 0	87 0	87 3	87 2½	—	—	—	—	—

* No prices available.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

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FOUNDRY MANAGER seeks position; thoroughly practical in all branches; good references; replies confidential.—Box 312, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

YOUNG NON-FERROUS FOUNDER, practical, studious, nearly nine years' jobbing foundry experience, seeks position of trust, progressive, home or abroad.—Box 310, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED, Foundry Foreman, production large high-class turbine and electrical work, responsible for iron mixtures; efficient organiser for maximum output. State age, experience, references, and salary expected.—Box 314, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

THE GOVERNMENT OF INDIA invite applications for five appointments of Assistant Engineer (Inspection) in the Indian Stores Department, three for structural and bridge inspection work, and two for mechanical engineering inspection work. Qualifications and conditions:—

A. **Structural and Bridge.**—A full apprenticeship in structural engineering workshops and drawing office experience. Special experience of structural steel and bridge work. Desirable candidates should have passed examination for Associate Membership of Institution of Civil Engineers, or of Institution of Mechanical Engineers, or of Institution of Engineers (India), or possess engineering degree qualifying for exemption. Pay, Rs. 500, rising by annual increments of Rs. 50 to Rs. 750 a calendar month, with a personal allowance of Rs. 200 a month and certain other allowances. Commencing rate of pay within this scale depends on age and qualifications.

B. **Mechanical Engineering.**—A full apprenticeship in mechanical engineering workshops and drawing office experience. Experience as working mechanic in shops. Candidates should have passed Associate Membership Examination, Institution of Civil Engineers, or Institution of Mechanical Engineers, or Institution of Engineers (India), or possess engineering degree qualifying for exemption.

Pay, Rs. 500, rising by annual increments of Rs. 50 to Rs. 750 a calendar month and certain other allowances.

A and B—age 24 to 35 years.

Free first-class passages to and from India. Provident Fund.

Further particulars and forms of application may be obtained upon request by postcard, stating which appointment desired, from the Secretary to the High Commissioner for India, General Department, 42, Grosvenor Gardens, London, S.W.1. Last date for the receipt of applications, October 7, 1929.

NOTICES.

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Borough Road, London, S.E.1.

ENGINEERING DEPARTMENT.

Evening Classes and Grouped Courses of Instruction are specially arranged for Apprentices, Improvers and Craftsmen in the Foundry Trade, the following subjects being included:—Foundry Practice, Workshop Processes, Metallurgy, Technical Drawing, Practical Mathematics, Engineering Science, Mechanics of Foundry Equipment, Chemistry of Metals, Foundry Management and Costs.

Enrolment, September 16, 18 and 20, 1929, 7 to 9 p.m.

Sessional Fees to London and Kent Students:
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Prospectus will be forwarded on application.

J. W. BISPHAM,
Principal.

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CITY OF LONDON.

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Jewry Street, Aldgate, E.C.3.

Principal:
GEO. PATCHIN, A.R.S.M., M.Inst.M.M.

DEPARTMENT OF METALLURGY.

The following special course of instruction will be given during the 1st and 2nd Terms (September to April) of the Session 1929-30, commencing Monday, September 23, at 7 p.m.

FOUNDRY PRACTICE.

By L. SINGLEHURST WARD, B.Sc., and A. F. GIBBS.

The course, which will consist of lectures, demonstrations and practical work in moulding and casting, is arranged for metallurgists and those engaged in Engineering and Foundry Work and will be of value to those interested in the production of all classes of castings.

Full particulars of the above course and also of the general courses given in the Department of Metallurgy may be obtained upon application to the Principal.

TENDER.

CITY OF SHEFFIELD.

The Lighting Sub-Committee of the City Council is prepared to receive Tenders for the supply of Lamp Pillars for the Lighting Department for the twelve months ending September 30, 1930.

Particulars and Form of Tender, together with Conditions of Contract, etc., may be obtained on and after Saturday, September 7, 1929, on application to the Lighting Engineer, 42, Corporation Street, Sheffield.

Tenders to be enclosed in the official envelope provided, endorsed "Tender for Lamp Pillars," and delivered not later than Saturday, September 14, 1929.

The Committee do not bind themselves to accept any Tender.

Any person or firm sending in a Tender will be required to add a schedule to such Tender stating the names of the various classes of labour which he or they intend to employ, together with the places where such labour will be employed, and the rates of wages, hours of labour and the conditions of employment to be paid and observed in respect of each class of labour, all of which as shown in such schedule shall comply with the City Council's form of clauses respecting wages, hours, and conditions of labour, and prohibition against assigning or sub-letting, a copy of which in the Conditions of Contract will be furnished with the Form of Tender.

J. F. COLQUHOUN,
Lighting Engineer.
Public Lighting Engineer's Office,
42, Corporation Street, Sheffield.
September 2, 1929.

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11 ACRES WORKS SITE.
SHEFFIELD.
145,000 Sq. Ft. of SHOPPING,
Compact and Convenient.
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Will Sell whole or in lots to suit customers or Let on favourable terms. Unique opportunity for Manufacturers.

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SAND MIXERS.—New and Secondhand. Ask us to quote.—W. BREALEY & COMPANY, LIMITED, Prospect Works, Hawksley Avenue, Sheffield.

B.S.A. Centreless GRINDING MACHINES, for work about 1¼ in. dia. x 6 in. long.

BLANCHARD Type Vertical SURFACE GRINDER, magnetic chuck 19½ in. dia.

No. 7A SUNDERLAND GEAR GENERATING MACHINE, capacity 18 in. dia. x 9 in. wide.

LANDIS 12 in. x 42 in. Plain GRINDING MACHINE.

3 ft. 0 in. GAUGE LOCOMOTIVE (Hudswell Clarke), cyls. 9 in. x 15 in.; copper firebox; brass tubes; 160 lbs. w.p.; steam and hand brakes.

2 ft. 0 in. GAUGE LOCOMOTIVE (Kerr Stuart, 1922 make), cyls. 6 in. x 9 in.; steel firebox and tubes; 160 lbs. w.p.; steam and hand brakes.

One VERTICAL COCHRAN BOILER, 11 ft. 3 in. high x 5 ft. 0 in. dia., re-insure 150 lbs. pressure.

18,000 ft. of new 2 in. diameter Screwed and Socketed PIPING in lengths of about 18/21 ft. to British Standard Specification and tested to 270 lbs. hydraulic pressure.

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